100% Design Report
Long-Term Stormwater Treatment
North Boeing Field
Seattle, Washington

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Prepared for

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LIST OF ABBREVIATIONS AND ACRONYMS

µg/L	Micrograms per Liter
µm	Micron
AKART	All Known, Available, and Reasonable Methods of Prevention, Control, and Treatment
ASAOC	Administrative Settlement Agreement and Order on Consent
Boeing	The Boeing Company
CESF	Chitosan-Enhanced Sand Filtration
City	City of Seattle
EAA	Early Action Area
Ecology	Washington State Department of Ecology
EOF	Emergency Overflow
EPA	U.S. Environmental Protection Agency
FAA	Federal Aviation Administration
FSP	Field Sampling Plan
g/yr	Grams per Year
gpm	Gallons per Minute
hp	Horsepower
KCIA	King County International Airport
LDW	Lower Duwamish Waterway
LTST	Long-Term Stormwater Treatment
mg/kg	Milligrams per Kilogram
mg/L	Milligrams per Liter
NBF	North Boeing Field
NTU	Nephelometric Turbidity Unit
O&M	Operation and Maintenance
PCBs	Polychlorinated Biphenyls
PLC	Programmable Logic Controller
QAPP	Quality Assurance Project Plan
RAWP	Removal Action Work Plan
SAP	Sampling and Analysis Plan
SEPA	State Environmental Policy Act
sf	Square Feet
SOW	Statement of Work
STST	Short-Term Stormwater Treatment
SWPPP	Stormwater Pollution Prevention Plan
TESC	Temporary Erosion and Sediment Control
TSS	Total Suspended Solids
VFD	Variable Frequency Drive
WAC	Washington Administrative Code
WISHA	Washington Industrial Safety and Health Act

1.0 INTRODUCTION

This document presents a 100% design for long-term stormwater treatment (LTST) at North Boeing Field (NBF). The U.S. Environmental Protection Agency (EPA) and Washington State Department of Ecology (Ecology) have been working with The Boeing Company (Boeing), the City of Seattle (City), and King County to eliminate sources of polychlorinated biphenyls (PCBs) in stormwater discharges to Slip 4 of the Lower Duwamish Waterway (LDW). On September 29, 2010, Boeing entered into an Administrative Settlement Agreement and Order on Consent for Removal Action (ASAOC) with the EPA. This document is a required deliverable under the ASAOC, which requires that Boeing address the discharge of PCBs to the Slip 4 Early Action Area (EAA) through short-term and long-term stormwater treatment removal actions. The short-term stormwater treatment (STST) system is currently installed and operational and consists of a chitosan-enhanced sand filtration (CESF) system that treats stormwater flow from a large portion of the North Lateral storm drain line at NBF.

The LTST system, which will replace the STST system, is required to be installed and operating by September 30, 2011. Remediation of Slip 4 sediments by dredging is scheduled to begin in the fall of 2011. As described in this document, the LTST system will consist of a larger CESF system than the STST system. The LTST system will continue to preferentially treat storm flows from the North Lateral (as the STST system is currently treating) but will be located at lift station LS431, where the system will be able to treat all storm drain base flow as well as a portion of all the storm flow that drains to the lift station and to Slip 4. In addition, Boeing will continue to perform source control actions to reduce PCB concentrations in storm drain solids.

1.1 PROJECT SITE DESCRIPTION

NBF is located east of East Marginal Way South, adjacent to the King County International Airport (KCIA) and the City of Seattle Georgetown Steam Plant. The approximate street address is 7370 East Marginal Way South, Seattle, Washington. NBF is approximately 150 ft from the head of Slip 4, which is an EAA at approximately River Mile 2.8 on the Duwamish Waterway within the LDW Superfund Site. The location of the site is shown on Figure 1.

1.2 PROJECT BACKGROUND

Boeing has conducted operations at NBF since the 1940s. NBF is used for research, flight testing, aircraft finishing, and delivery facilities. Stormwater from NBF is collected and conveyed by storm drains to Slip 4 of the LDW. In 2001, the LDW was placed on the National Priorities List (Superfund) pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act.

In 2003, the sediments and portions of the bank in Slip 4 were identified as an EAA due to the presence of PCBs in the sediment. Prior to cleanup of Slip 4, Ecology determined that ongoing sources of PCB discharges to Slip 4 should be controlled to reduce the likelihood of recontamination of the sediment following cleanup. Previous investigations at the NBF site identified the presence of PCBs in solids in manholes, catch basins, sediment traps, and in water in the NBF storm drain system, which discharges to Slip 4 via the KCIA Storm Drain #3 PS44 Emergency Overflow (EOF) shown on Figure 2.

As defined in the ASAOC, “stormwater” shall mean all liquids, including any particles dissolved therein, in the form of base flow, stormwater runoff, snow melt runoff, and surface runoff and drainage, as well as all solids that enter the storm drainage system. “System,” when used in the context of storm drainage, shall mean the combination of all manholes, catch basins, pipes, and other drainage devices and conveyances designed, constructed, and used for the purpose of carrying stormwater from NBF to Slip 4 of the LDW, and the drainage basin associated with these devices and conveyances.

The majority of PCBs discharging from NBF to Slip 4 via the NBF storm drain system were previously identified to be from the North Lateral portion of the storm drain (SAIC 2010). Under the ASAOC, Boeing installed an STST facility to remove PCBs from a large portion of the North Lateral portion of the NBF storm drain system prior to discharge to Slip 4 (Landau Associates 2010a, 2011a). The STST facility was placed into continuous operation on September 15, 2010 and will continue to be operated under the oversight of the EPA until the LTST facility is installed and operating. During operation of the STST facility, samples of the storm drain system solids and stormwater have been collected to monitor compliance with the Interim Goals established by the EPA for the STST facility, to evaluate performance of the STST facility, and to support design of the LTST facility.

2.0 TECHNICAL BASIS OF SYSTEM DESIGN

As was similarly described in the Long-Term Stormwater Treatment Removal Action Work Plan (RAWP) Addendum (Geosyntec Consultants 2011a) and Final Pre-Design Technical Memorandum: Long-Term Stormwater Treatment (Geosyntec Consultants and Landau Associates 2011), the following items describe the basis of LTST system design.

- The CESF system will be constructed at (just south of) the King County lift station (LS431) to treat all dry weather base flows from the lift station and preferentially treat wet weather storm flows from the North Lateral from MH130A and, as capacity allows, additional flows from the lift station. The treatment system location and sizing will result in approximately 91 percent capture and treatment of onsite storm flows to MH130A (12.8 acres), and 100 percent treatment of onsite and offsite dry weather base flows to the lift station (approximately 106 acres onsite plus approximately 191 acres offsite). Additional treatment of low storm flows at the lift station will also be provided when capacity is available. The system will operate at full capacity (1,500 gpm) whenever sufficient stormwater is present.
- The existing STST submersible pump at MH130A will be connected to a new force main to route wet weather storm and base flows from the onsite North Lateral directly to the CESF treatment system at the lift station. When LTST system capacity exists beyond that required to treat the "captured" onsite North Lateral storm flows, additional storm flows from the lift station will be pumped to the CESF to take advantage of the full system treatment capacity.
- Offsite stormwater from the North Lateral (41.1 acres of King County drainage) will be rerouted at a location upstream of MH178 through NBF to the lift station, upstream of the CESF intake. The purpose of this reroute will be to minimize overflow bypass at MH130A and allow preferential capture and treatment of onsite North Lateral storm flows. The reroute will also allow some treatment of offsite North Lateral flows (as well as other laterals) when capacity allows.
- Dry weather base flows from onsite and offsite laterals discharging to the lift station will be pumped to the CESF, which will discharge to the lift station outfall vault, downstream of the CESF intake.

The NBF onsite and offsite areas that drain to the lift station and that can be treated by the LTST system, up to its maximum 1,500 gallons per minute (gpm) treatment capacity, are shown on Figure 3. The boundary of the specific area that drains to MH130A is shown on Figure 4. Treatment system sizing and treatment system design are described in greater detail in the following sections. Design plans of the LTST system are provided in Appendix A, and design plans for the storm drain reroute and modifications prepared by URS Corporation are provided in Appendix B.

2.1 INTERIM GOALS

As feasible, the LTST system and source controls will be designed to meet the long-term Interim Goals outlined in the ASAOC statement of work (SOW) for PCBs at the point of compliance. The Interim Goals listed in the ASAOC are included in Table 1 below.

TABLE 1
LONG-TERM INTERIM GOALS FOR PCBS IN WATER AND SOLIDS

Matrix	PCB Criterion	Reference	Value
Water	Aquatic Life - Marine/Chronic Interim Goal	EPA and Boeing 2010 EPA 2011	0.030 µg/L
Solids	Total dry weight current Interim Goal – pending EPA review and consideration of AKART for CESF	EPA and Boeing 2010	0.1 ppm (mg/kg)
	Alternative dry weight criterion of the sediment quality standard adjusted for site-specific total organic carbon	Landau Associates 2010b	0.42 ppm (mg/kg)

The LDW is a tidally-influenced water body with variable salinity depending on location, tidal conditions, flows, and stormwater influences. Applicable water quality criteria (marine or freshwater) for Slip 4 are dependent upon the salinity levels within the slip. Salinity monitoring results indicate that the marine chronic aquatic life standard of 0.030 µg/L total PCBs applies to Slip 4 (AMEC 2011). The EPA issued a formal approval of the salinity monitoring report on June 20 (EPA 2011).

There have been previous discussions regarding the applicability of the EPA Interim Goal for solids (Geosyntec Consultants and Landau Associates 2011). The EPA is currently evaluating the applicability of this interim goal and considering CESF as potentially meeting the definition of AKART for this particular project.

As noted to EPA in previous correspondence (Landau Associates 2011b), the CESF system works by removing suspended solids and associated PCBs. CESF does not remove PCBs from total suspended solids (TSS) particles and then eject clean particles back out to the effluent. Therefore, CESF [or any other viable treatment technologies identified in the AKART analysis for this project (Geosyntec Consultants 2011b)] is not capable of reducing the concentration of PCBs in suspended solids, and the PCB solids Interim Goal of 0.1 milligrams per kilogram (mg/kg) dry weight cannot be (and has not been) incorporated into the CESF treatment system design basis. CESF is very effective at reducing the mass of TSS and PCBs in the stormwater (i.e., the whole water concentration) as demonstrated through STST operation since September 15, 2010. The PCB mass reduction is what is of primary importance relative to potential Slip 4 sediment recontamination, given the net deposition of solids from many sources beyond NBF stormwater.

Monitoring of NBF stormwater to assess the performance of the CESF system and to assess compliance with applicable Interim Goals, is described in Section 2.5.1. A Sampling and Analysis Plan (SAP) for the LTST is provided in Appendix C. An Operation and Maintenance Manual for LTST has been prepared to ensure proper system performance, which is provided in Appendix D.

2.2 TREATMENT SYSTEM SIZING

Following the determination of the LTST design basis described above, it was necessary to determine the size of the system (i.e., its flow rate capacity). Given a full NBF drainage basin area of approximately 303 acres, it is not feasible to treat all the stormwater runoff from all storm events. A cost benefit evaluation was conducted, and as described in the LTST RAWP Addendum (Geosyntec Consultants 2011a), a range of 750 to 1,500 gpm was identified to be within the "knee of the curve" (or the point of diminishing returns) range for both the volume capture and PCB load reduction curves. Boeing and EPA then agreed on an acceptable sizing design basis of 1,500 gpm (Geosyntec Consultants and Landau Associates 2011).

A 1,500 gpm CESF system, including a minimum 500 gpm pump capacity at MH130A, is also anticipated to achieve a long-term average volume capture at LS431 of 81 percent of runoff from onsite drainage only, and 59 percent of runoff from combined onsite and offsite drainage areas. A portion of storm flows from other laterals, all of which are routed to the lift station and commingled, will also be treated based on available capacity in the LTST system. The CESF system will be operated at full capacity (1,500 gpm) whenever sufficient stormwater is present.

As described in the LTST RAWP Addendum (Geosyntec Consultants 2011a,c), the 1,500 gpm LTST system is predicted to achieve a total PCB load reduction of approximately 73 percent annually [or approximately 96 percent in dry weather (reduced from 6.7 to 0.24 grams per year [g/yr]) and approximately 68 percent in wet weather (reduced from 32 to 10.4 g/yr)]. It is also anticipated that the LTST system will comply with the freshwater and marine Interim Goals for water approximately 96 percent of the time during a "typical" year (or 100 percent of dry days and 90 percent of wet days per year) based on rough estimates using limited available water and filtered solids dry and wet weather monitoring data.

2.3 TREATMENT SYSTEM DESIGN

The CESF treatment process for the LTST system will be similar in configuration and operation to the current STST system, although significantly larger in footprint and capacity. As outlined in the RAWP for STST (Landau Associates 2011a), the treatment processes include coarse solids settling in aboveground settling/storage tanks, solids coagulation via chitosan acetate dosage [less than one part per million (ppm) of chitosan acetate solution containing the natural biopolymer chitin], sand filtration through a bank of sand filter units to remove the coagulated solids, and automated sequential backflushing of the sand filter units to maintain the necessary system treatment capacity and associated TSS and PCB removal efficiency. This approach has proven effective for removing PCBs in water by the NBF STST system.

The main components of the 1,500 gpm sized system are one inlet weir/settling tank and one backwash solids settling tank (each approximately 18,000-gallon capacity), three storage tanks (approximately 21,000-gallon capacity), three sand filter systems each consisting of four individual 54-inch diameter sand filter vessels, and a control system housed within a container or structure (e.g., rail container box, shed, trailer, etc.). The treatment system equipment is shown in the design plans in Appendix A.

There will be three independent sand filter systems that are sized to each treat a design flow rate of 500 gpm, with filtration capacity of up to 700 gpm for temporary processing of backwash water or treated stormwater that is recirculated for additional treatment. The purpose of three independent sand filter systems is to allow portions of the treatment system to operate more continuously during low-flow conditions, to keep the size of the system components to within a range that avoids larger special-order equipment, to allow more flexibility in maintenance (ability to take one of the systems off-line for periodic maintenance), and to allow for potential downsizing of the system in the future. Each of the three sand filter systems is the same four-vessel (each a 54-inch diameter vessel) unit that is currently used for the STST and that is specially modified by the chitosan system supplier. A specification sheet for the modified sand filter system is provided with the system calculation and equipment data in Appendix E.

Given the available filtration surface area of approximately 64 square feet (sf) for a four-vessel sand filter unit, a 500 gpm flow results in a sand filter loading of approximately 7.9 gpm/sf. This design loading is well within the Ecology general use designation for CESF at 15 gpm/sf, and that use designation is for construction stormwater projects with much higher TSS loading compared to the NBF site. Even during backflush cycles (under higher back-pressure and reduced flow rate) when flow is routed through only three of the four sand filter vessels, the filter loading is not expected to exceed 10 gpm/sf. This planned moderate hydraulic loading rate is equivalent to current STST operation and will allow for continued effective filtration of TSS and PCBs, will result in lower pressure drop across the sand filters, and will thereby reduce the size of pumps required and minimize power consumption.

The sand filter backwash water will be discharged to an 18,000-gallon backwash settling tank. Backflushing will be automated and sequenced with backwashing occurring at one vessel at a time, which will minimize backwash flow rates. With a design backwash flow rate of only 239 gpm, there will be a relatively long hydraulic retention time in the backwash tank to allow for very effective settling of backwashed solids. Representative calculations performed to confirm sizing and selection of tanks, pumps, and pipe diameters are provided in Appendix E.

Boeing has worked to identify and set aside space near the lift station for the LTST system. The 1,500 gpm size CESF system will fit within an area of approximately 7,000 sf just south of the lift station.

The plan view of the proposed layout of system equipment is shown on Drawing C505 (Appendix A). Prior to LTST system construction, it is planned that an existing idle nitrogen tank just north of the lift station and its protective bollards would be removed, which will help to partially offset available parking space lost to the LTST system.

2.3.1 STORMWATER COLLECTION PUMP OPERATION AND CONTROL

Stormwater will continue to be pumped from the North Lateral out of MH130A and treated. The existing submersible pump at this location produces approximately 540 gpm. A new buried stormwater conveyance pipe will be installed from MH130A to the lift station (details shown in Appendix B), and stormwater pumped from MH130A will be pumped directly into the weir tank at the new lift station CESF system. The design for the piping to the lift station, despite the longer piping length, will allow continued stormwater pumping from MH130A at a design flow rate of 500 gpm.

The spare treatment capacity that remains at the 1,500 gpm CESF system after treating flow from MH130A will be taken up by pumping available base flow and stormwater from the lift station. The CESF system will be operated at full capacity (1,500 gpm) whenever sufficient stormwater is present.

A submersible pump will be installed in the inlet vault of the lift station. The inlet vault is referred to as OWS421 in Boeing storm drain drawings. However, the vault structure is not a baffled oil/water separator as might be inferred by its reference number. The inlet weir tank on the LTST system is designed with an underflow baffle to help contain floating fuel/oil if spilled fuel were to drain to the lift station and the submersible pump were to pump fuel into the CESF system before someone identified the spill.

Typically, sludge does not collect in OWS421 due to the turbulence generated by incoming stormwater and the activation of the large 50 horsepower (hp) King County lift station pumps; however, heavier sand particles may accumulate in the corners and sides of the lift station sump where turbulence is lower. While the proposed pump plan is not anticipated to alter the accumulation of sludge in OWS421, settled solids in the lift station vault will be monitored upon LTST system startup. The initial transfer pump (pre-treatment pump, P-301) is designed to pass up to 7/8" solids, and the inlet weir tank will allow settling of solids that size or larger. The inlet flow meter will be an electromagnetic flow meter and will not have a turbine wheel or paddle wheel to catch solids or debris. Basket strainers are currently part of the design at the two system inlets (Drawing K501, Appendix A) and will allow greater assurance of pump protection against neutrally buoyant debris that might pass through the inlet weir tank and get caught in the primary transfer pump.

Currently, there are no plans to pump out of the lift station OWS421 with a preference for collecting stormwater from one storm drain lateral pipe over another, meaning that all stormwater (other than the water pumped from MH130A) will mix together in OWS421 and will be pumped out without regard to specific lateral. However, if future lift station discharge compliance sampling indicates that applicable PCB criteria are not being met, then contingent actions may be implemented as described in Section 2.4.

The aboveground inlet weir tank and three storage tanks will have water level sensors that will be used to adjust pump operation through programmable logic controller (PLC) control. Flow rate data from the inlet flow meters will also be monitored and the OWS421 submersible pump can be deactivated or its motor slowed down by variable frequency drive (VFD) adjustment in the event that more than the 1,500 gpm design flow rate is exceeded for a period of time. Therefore, normal system controls will act to prevent a tank overflow event. As an additional safety device against tank overflow in the event of level measuring device failure, high water level switches will be installed at the inlet weir tank and the connected set of storage tanks to shut down the lift station submersible pump and/or the 1,500 gpm pre-treatment pump until the tank levels are back within the normal operational range. Finally, a tank high level overflow pipe will be installed on the inlet weir tank and the connected set of three storage tanks, as indicated on the system drawings in Appendix A. The overflow pipes will allow some amount of overflow directly back to the lift station inlet vault, without overflowing the top of the tank, in the unlikely event of failure or delay from the other tanks' level controls and pump controls. The overflow piping is sized to allow overflow of more than the 500 gpm flow rate from the MH130A pump (which is not directly controlled by the main CESF control unit) back to OWS421.

The submersible pump in OWS421 will be set to activate (using a pressure transducer level reading) at a level below that which any of the four 50-hp King County pumps activate (see Drawing K501, Appendix A). This new submersible pump would also be set to turn off at a level that is above the manufacturer's minimum recommended submergence depth in order to avoid motor overheating or dry run conditions. Note that with the use of the submersible pumps, the frequency of the King County pumps being activated will decrease significantly (expected never during base flows and less often than normal during storm events) and therefore the energy use of the stormwater pumping portion of the LTST system will be offset by power saved with the decreased use of the lift station pumps.

2.3.2 CESF SYSTEM INSTRUMENTATION AND CONTROLS

The design of the CESF system includes the necessary instrumentation and controls for the system to monitor and record relevant data and to control the pumps, valves, and filters for the system to meet its design objectives. Instrumentation will be provided as indicated on the design drawings (Appendix A) to conduct the following monitoring and control functions:

- Real-time monitoring of water levels in the lift station inlet vault, in the inlet weir settling tank, and in the set of three storage tanks will be performed using pressure transducers (or alternatively, using ultrasonic sensors).
- Inlet stormwater flow rate and total flow from both MH130A and from the lift station will be monitored by both real-time monitoring and data recording. The mounting locations of these flow meters are below ground within a vault, as shown on the conveyance piping plan set (Appendix B).
- With the real time monitoring of water levels and flow rates, the system PLC will turn pumps on and off, as appropriate, and control their flow rates using VFDs to pump and treat the full design flow rate of 1,500 gpm when that flow rate is available, while at the same time avoiding pumping more than 1,500 gpm of stormwater into the treatment system and avoiding overfilling either the inlet weir tank or the three connected storage tanks.
- Both recirculation (re-treated) flow volume and effluent discharge stormwater flow rate and total flow will be monitored by both real-time monitoring and data recording.
- PLC-based control of sand filter backflushing will be triggered based on maximum time interval and based on differential pressure rise. Backflushing will be controlled by the PLC to allow backflushing of only one of the three sand filter systems at a time, to minimize spikes in treatment system flow rate above the 239 gpm design backwashing flow rate per vessel. The duration of backflushing will also be adjustable and will initially be set to 90 seconds per vessel.
- Continuous monitoring and recording of influent and effluent turbidity (which correlates to TSS and thereby also to PCB concentration) will be provided. There will be automated recirculation triggered if filtered stormwater exceeds a selected turbidity setpoint. The initial control setpoint is anticipated to be set at 5 nephelometric turbidity units (NTUs), as indicated on Drawing K503 (Appendix A).
- Monitoring and recording of effluent pH will be provided. The NBF facility is covered under the Industrial Stormwater General Permit issued by Ecology, which establishes a pH benchmark range of 5 to 9 standard units. There have been no data from past STST CESF system operation that have indicated influent or effluent pH outside of that range. Therefore, there will be no active pH alarms or controls on the LTST system, only pH monitoring.
- The CESF system will include four independent and PLC-controlled chitosan metering pumps. Static mixers will be provided in the lines just downstream of the chitosan injection points in order to thoroughly mix the chitosan into the stormwater.
- The PLC will be programmed to conduct alternating starts of the sand filter systems and their associated pumps. The alternating starts will allow the sand filters to equilibrate their operational hours.
- Remote calling/texting will alert operations personnel of any abnormal conditions including long periods in recirculation mode, abnormally high effluent turbidity, pH outside the range of 5.5 – 8.5, high tank water level that is not corrected within an allowable time, evidence of pump failure.
- Solids filter assemblies constructed of steel and using 1-micron nominal rated filter bag elements will be provided at the MH130A influent line, the lift station influent line, and the CESF system effluent line. Each filter will also be installed with a downstream flow totalizer to record volume filtered.

The CESF system supplier and operator (Clear Water) maintains spares of all their general system equipment (e.g., chitosan metering pumps, turbidity meters, valves, instrumentation). Therefore, system operational repairs that may be required can generally occur without delay (see Section 2.3.4).

2.3.3 GREEN REMEDIATION POLICY

Consistent with the EPA Region 10 "Clean and Green Policy" to enhance the environmental benefits and sustainability of federal remediation programs at Superfund sites, the following are the green technologies identified in the policy and their applicability to the planned project at NBF:

- **100% use of renewable energy (green power), and energy conservation and efficiency approaches including EnergyStar equipment –** Boeing has made arrangements to purchase 100% renewable energy through the Seattle City Light *Green Up* program. Boeing will purchase the power as an "Event" for the estimated 200,000 kilowatt-hours (kWh) required to operate the CESF system for each year of operation. The power use was estimated from a maximum system power draw of 120 hp (90 kW) and an average system utilization of 25% considering both estimates of base flow and storm flow. High quality pumps with efficient motors have been specified for the project. It does not appear that EnergyStar certification is available for the large pumps and other equipment needed for the CESF system, but VFDs will be used for the pumps as described below.
- **Cleaner fuels, diesel emissions controls and retrofits, and emission reduction strategies –** Requirements regarding cleaner fuels and emission reduction strategies will be added to the contractor specifications, as listed below.
- **Water conservation and efficiency approaches including WaterSense products –** Backwashing of sand filters can be performed with filtered stormwater or from a potable water source. The STST and LTST are designed to use filtered stormwater, and no supplemental water is used as part of the routine CESF treatment process at NBF. Even the non-routine removal of settled solids from weir and storage tanks will be generally performed with a vacuum truck without use of a supplemental water source, although a small quantity of water may be used for tank clean-out if determined to be necessary for effective solids removal.
- **Sustainable site design –** The LTST stormwater conveyance piping is designed with spare piping connections to allow potential future incorporation of a vegetated media filtration basin for stormwater treatment, which could reduce the electrical power required for stormwater treatment.
- **Industrial material reuse or recycling within regulatory requirements –** The large steel enclosure for the NBF CESF system control unit and some of its components are equipment from a previous project and are being refurbished for reuse at NBF. Reuse or recycling of piping or other CESF system equipment was not deemed to be practical for this project. Piping and other CESF system equipment from other projects cannot be used on this project because other treatment systems from the CESF system supplier (Clear Water) have been designed and installed for short-term duration projects. The piping and equipment specified for this project are designed for a planned operational life of 20 years.
- **Recycling of materials generated at or removed from the site –** The asphalt that is saw-cut and removed from the facility for the trenching work will be sent to an asphalt recycling facility. All excavated suitable soil that is tested and deemed acceptable for reuse will be

used as backfill for pipe trenching work, to the extent possible. Soil that is shipped offsite for disposal will be sent to the Waste Management Alaska Street Reload Facility for rail shipment to Columbia Ridge landfill. Shipment by rail reduces single truck traffic to the landfill, and soil will be recycled for use as daily cover.

- **Environmentally Preferable Purchasing –** The general contractor will use local import backfill materials to the extent practicable and to the extent that onsite excavated soil cannot be reused. Log books and other paperwork associated with the CESF system operation and maintenance will incorporate post-consumer recycled content to the extent reasonably available. Post-consumer-recycled (PCR) content is not available for HDPE piping because this material is typically manufactured for potable groundwater. All ductile iron pipe and fittings will be made from material ranging from 85% to 90% recycled metals.

- **Greenhouse gas emission reduction technologies –** This LTST system does not employ use of boilers, diesel generators, or other onsite combustion sources, so this item is not considered applicable to the project.

- **Concrete made with Coal Combustion Products replacing a portion of traditional cement –** The project uses a relatively small volume of concrete for the CESF system equipment pad, so it was not deemed practical to integrate coal combustion products into the project. Additionally, the EPA coal combustion partnership program has been temporarily suspended.

- **Capture landfill gases under the Landfill Methane Outreach Program –** This is not a landfill project, so this item is not applicable to the project.

- **Environmental Management System (EMS) practices such as reducing the use of paper by moving to fully electronic transmittal of project documents and implementation of waste reduction and recycling programs at all work sites –** Boeing is preparing electronic submittals to EPA for the documents under this project, and avoiding use of paper copies/submittals, to the extent allowed by EPA under the ASAOC.

In addition to the standard EPA green technologies listed above, the LTST system design incorporates the following technologies and practices listed below.

- Typical implementation of CESF systems is to maintain a constant backpressure on the system to ensure adequate backflow through the sand filter during a backwash cycle, without the use of a supplemental pump. This backpressure would be created by using a partially closed valve, and this higher operational pressure would result in the need to purchase and operate pump(s) at a higher horsepower than would be necessary for normal sand filtration operation. However, testing was performed during STST operation where a motorized and automated discharge valve was installed and was throttled back only during the backwash cycle to create the necessary higher backpressure. This system modification was found to be successful and will also be installed for the three sand filter units used in the LTST system. This system improvement will reduce operational power requirements.

- VFDs will be used to control the five new LTST pump motors. The use of VFDs for pump motor controls will help to reduce power use by running the pumps only at the speed necessary for the system's need at that time. The existing MH130A pump is properly sized for its operation, and no significant benefit is seen in adding a VFD for its operation since its flow rate will be fixed for all conditions.

- The natural chitosan polymer used in the CESF process (chitin) is produced from waste shrimp and crab shells, rather than a synthesized chemical or a product of petroleum processing.
- The CESF process generates a smaller amount of solid waste that contains PCBs and that needs to be disposed of at a landfill, relative to other potential treatment technologies (e.g., granular-activated carbon, media filtration).

As noted in the "Clean and Green Policy," Region 10 intends to measure the cost differentials and environmental benefits associated with implementing the policy. Examples include, but are not limited to, tracking quantities of materials reduced, reused, or recycled; carbon or greenhouse gas reductions; and water conserved or replenished. To support this effort, the Removal Action Completion Report will include a summary of all actions implemented consistent with the "Clean and Green Policy." Estimates of the quantities of materials reduced/reused/recycled, carbon or greenhouse gas reductions, etc., will be summarized and tabulated or presented in graphics. As best possible, costs associated with implementation of these measures shall also be summarized. For example, project costs associated with the purchase of an "Event" with the Green Up program can be compared with costs if electricity was not purchased through the Green Up program.

The following specifications will be included in the construction contract or in a construction contract amendment:

1) Green Policy: The contractor shall use technologies and practices that are sustainable in accordance with EPA Region 10 Green Cleanups (http://yosemite.epa.gov/R10/extaff.nsf/programs/greencleanups), with the exception of the use of concrete utilizing coal combustion products (see EPA suspension of coal combustion products partnership program, http://www.epa.gov/osw/partnerships/c2p2/index.htm). The contractor shall report on the use of these technologies and practices, including the associated quantities of materials reduced, reused, or recycled as a direct result of these practices, for all remedial activities conducted under this contract after project completion.
2) Cleaner fuels, diesel emissions controls and retrofits, and emission reduction strategies: For diesel-powered equipment exceeding 50 hp, the contractor will utilize construction equipment rented from a local supplier, and will request the rental of construction equipment meeting Tier 4 standards. If Tier 4 construction equipment is not available, equipment will be requested that meets at least the Tier 3 standards. If equipment meeting Tier 4 or Tier 3 standards is not available, then other equipment may be considered if emission devices are added such as oxidation catalysts and/or particulate filters. Equipment with a higher tier emission standard will not be used if the only available selection is larger equipment that would use more fuel or result in a higher rate of emissions.
3) Clean Fuel: Cleaner fuels will be used in all diesel-powered equipment. Diesel fuels to be used may include biodiesel blends (e.g., B5 or B20). Ultra low sulfur diesel is now legally required for all applicable equipment (this is not a contract requirement).
4) Greenhouse gas emission reduction technologies: Diesel-powered equipment should be used where available instead of gas-powered equipment. The Contractor shall minimize idling to control air pollution and reduce fuel usage. This shall include turning off all diesel engines

on construction equipment greater than 50 hp when not in active use (e.g., on standby for more than 5 minutes).

5) Water conservation and efficiency: If water consumption is necessary (e.g., for dust suppression), water conservation measures will be utilized where feasible.

6) Industrial material reuse or recycling within regulatory requirements: Where feasible, the contractor shall recycle all scrap construction materials, wastes from the construction trailer, and other materials generated during the course of construction activities.

7) Environmentally Preferable Purchasing: Where available, all materials purchased will have Post-Consumer Recycled (PCR) content. Ductile iron pipe and fittings shall be made from 85-90% recycled metals.

8) Environmental Management System (EMS): Practices such as reducing the use of paper by utilizing electronic transmittal of project documents and implementation of waste reduction and recycling programs at the work site shall be implemented. The contractor shall also provide all recycling services possible through local waste management services for the site trailer, such as waste management recycling and compost containers for site workers. Workers will also be encouraged to minimize waste where possible, e.g., using refillable water bottles instead of single-use bottled water.

9) The Contractor shall purchase and use local materials (such as asphalt and backfill material) where available.

2.3.4 SYSTEM RELIABILITY AND DISCHARGE WATER QUALITY

As has been the case for the STST CESF system operation, the LTST CESF system is designed to provide reliable operation and to have minimal downtime. With automated remote notification of alarm conditions, it is expected that any problems can be quickly addressed. It is also expected that during the first months of the LTST CESF system operation that there will be some minor startup and operational issues to be worked out as has been the case with the STST system. However, the lessons learned during STST startup and operation have been used to improve system design and should help to minimize startup and operational problems.

Duplicate spare pumps will not be provided onsite, as the design life of these pumps is for many years of reliable operation. However, in the unlikely event of pump failure, the CESF system operator (Clear Water) typically has spare pumps available and a full range of pumps is available through local rental companies. With the remote notification of CESF system alarms and the available rental fleet of pumps, the system downtime following an unlikely pump failure would be minimal. Also, as noted above, the CESF system supplier and operator (Clear Water) maintains spares of all their general CESF system equipment (e.g., chitosan metering pumps, turbidity meters, valves, instrumentation). Therefore, system operational repairs that may be required can generally occur within 12 hours. The goal for operation of the CESF system will be achieving a minimum of 97 percent uptime on an annual basis.

In terms of effluent water quality, out of 27 weekly STST CESF system effluent grab samples through April 5, 2011, none of the samples have exceeded a TSS concentration of 1.5 mg/L (typically non-detect at less than 1 mg/L) and with only one exception the discharge samples have had a concentration of total PCBs that has not exceeded the 0.014 µg/L freshwater criterion. All CESF discharge samples have been well under the 0.030 µg/L marine water criterion that applies to discharge to Slip 4.

As discussed in the LTST RAWP and Addendum [Geosyntec Consultants 2011a,c], the 1,500 gpm LTST system is predicted to achieve a total PCB load reduction of approximately 73 percent annually [or 96 percent in dry weather (reduced from 6.7 to 0.24 g/yr) and 68 percent in wet weather (reduced from 32 to 3.4 g/yr)].

2.3.5 MODIFICATION TO STORMWATER TREATMENT DRAINAGE AREA

A recent change that has been incorporated into the project design since the 90% Design Report was prepared is the addition of a new storm drain line from the Markov (7-107 Building) recycling and refuse handling yard (CB102A to CB104). This change re-routes stormwater from that drainage area, at the northwestern portion of NBF, to drain to the lift station and be included with the area that receives stormwater treatment. The size of this drainage area that is being rerouted to the lift station is approximately 0.5 acres. Figure 2 and the project drawings (Appendix A) have been updated to show this planned modification.

2.4 DESIGN FLEXIBILITY AND CONTINGENCIES

The LTST piping design includes a valve box in the north portion of the site that will allow for potential future installation of a media filtration basin at that location, as has been discussed as an option with EPA, without having to excavate and modify the stormwater conveyance piping (see Appendix B drawings, Sheet C295 and M502). Using a media infiltration basin for stormwater treatment is still being evaluated for potential future implementation at NBF.

Consideration has also recently been given to the installation of spare stormwater conveyance piping and spare electrical/control conduit that could potentially be used as part of a media filtration basin stormwater treatment system. To account for this possible future contingency, a spare 6-inch or 8-inch diameter force main HDPE pipe and spare electrical conduit(s) may be added to the trench from the lift station to the valve box at the potential future media filtration basin. Additionally, spare electrical conduit(s) may be added in the trench that runs from near the MH130A pump control panel to the potential future media filtration basin. The project design plans (Appendix A and Appendix B) have not yet been fully updated to include these spare utilities.

The piping design also includes a vault structure (wet vault) on the offsite flow reroute pipe, just upstream and north of the discharge to the lift station (see Appendix B drawings). That wet vault will allow for potential installation of a pump on this rerouted line to directly pump the bypassed King County stormwater to Slip 4 if it is later determined that the offsite King County flow is negatively affecting the LTST capability of meeting applicable water quality discharge criteria. Related to this, a weir structure and pressure/level transducer will be installed in this wet vault (see plans in Appendix B) or other upstream location to provide for monitoring and to estimate the flow rate in this storm drain line. Filtered solids and whole water sampling will also be conducted for this King County storm drain at the wet vault location or other upstream location, as described in the SAP (Appendix C).

2.5 OPERATION, MAINTENANCE, AND REPORTING

The operation and maintenance (O&M) of the LTST CESF system will be similar to that of the current STST system. Appendix A of the STST Removal Action Work Plan (Landau Associates 2011a) included a detailed description of operation, maintenance, and monitoring of the STST system, and the procedures included in that manual are generally applicable to the LTST system. A new O&M Manual for LTST has been prepared and is provided as Appendix D. A summary of the prominent O&M tasks and description of LTST specific tasks is given below.

CESF systems are most frequently operated at construction sites where very turbid water (on the order of thousands of NTUs) is being treated, are operated intermittently, and are actively operated by trained personnel. Operation at NBF will differ in that treatment will take place 24 hours a day to treat base flow (although this may use only one of the three sand filters, allowing equipment maintenance to occur on a non-rush basis during dry weather) and storm flow, treating water with turbidity typically less than 25 NTU. Therefore, similar to the STST system, once the system is determined to be operating properly, operation and monitoring will be automated, leaving only weekly calibration and a routine inspection to be conducted by trained CESF operators. A remote messaging alarm system will alert personnel if additional unscheduled/immediate maintenance is needed.

Monitoring of the CESF system during operation will include residual chitosan testing, routine inspections, and sensor and chitosan metering pump calibrations. Once the CESF system is optimized and operating smoothly, the chitosan dosing rate is anticipated to remain constant, and a twice-monthly residual chitosan testing frequency is anticipated to be adequate to verify that no chitosan is being discharged to Slip 4. The monitoring frequency is listed in the SAP (Appendix C) and in the Operation and Maintenance Manual (Appendix D); this proposed residual chitosan monitoring is a slight decrease in frequency from what is listed in the STST RAWP O&M Manual (Landau Associates 2011a).

Breakthrough of PCBs through the sand filter media at very low levels was seen at the STST system after 6 months of operation and after the four-vessel system had filtered more than 20 million gallons of stormwater. Therefore, special attention will be paid to each of the three sand filter systems as they approach or pass the point of having filtered 20 million gallons. Sand filters will also lose some of their sand during the backwash cycles, so it is planned to open up the sand filters after every 5 million gallons filtered to see if replacement sand is necessary to bring the filter media bed back up to its full height. Replacement of the filter media after treatment of over 20 million gallons may not be necessary if sand media volume is maintained and effluent water quality is meeting the design basis.

2.5.1 MONITORING

Treatment system performance monitoring and site compliance monitoring will continue during the LTST, in a similar manner to monitoring conducted during STST operation. The details of planned monitoring are provided in the SAP (Appendix C), which includes a Field Sampling Plan (FSP) and Quality Assurance Project Plan (QAPP). Changes have been proposed to the monitoring locations, parameters, and frequency based on demonstrated CESF system performance during STST operation and based on changed system location and configuration.

2.5.2 COMPLIANCE POINT

The King County lift station (LS431) is identified as the point of compliance since storm drain discharges here represent 94 percent of the NBF onsite drainage area. The remaining 6 percent of the area is known to have relatively lower PCB solids concentrations (Landau Associates 2011a). The lift station is also the farthest downstream location in the storm drain system that is not impacted by tidal flushing and PCB-containing sediments from Slip 4. Downstream of the lift station, such as CB433 or at the outfall, water and solids samples would not be representative of solely NBF storm drain discharges (note that the lift station also does currently include significant upgradient offsite contributions). It is proposed that the LTST point of compliance remain in its current location downstream of the lift station pumps, which will also be just downstream of the point at which the CESF effluent is discharged. The drawings in Appendix A also illustrate the point of compliance.

2.5.3 REPORTING

Until such time that EPA approves of alternate reporting requirements, Boeing will continue to prepare monthly progress reports and submit those reports to EPA by the fifth day of the following month (or the first subsequent work day if the fifth day of the month falls on a weekend or holiday). Monthly progress reports will continue to include information related to stormwater treatment system operation (e.g., total gallons of stormwater treated, rainfall data, any significant operational problems or system shutdowns) and will contain summary data tables of all validated stormwater analytical testing results that were received from the laboratory by the 24th of the month. Results of the Stage 2A data validation, as described in the SAP, will be documented in a technical memorandum. The technical memorandum will include a disk with electronic copies of chain-of-custody forms and laboratory data packages, and submitted to EPA with project monthly reports.

3.0 PROJECT CONSTRUCTION AND SCHEDULE

This project has a relatively quick schedule. However, there are no currently identified barriers to completion of the design, procurement, and construction work in time for having a complete CESF treatment system operational by the September 30, 2011 deadline established in the ASAOC. A project organization chart is provided on Figure 5 to help clarify project responsibilities.

3.1 PROJECT CONSTRUCTION

Boeing plans to use two primary contractors for construction of the LTST project. One contractor will be the CESF system contractor/supplier, Clear Water Compliance Services, the CESF system contractor that supplied, installed, and operated the STST system. Clear Water will be subcontracted through Landau Associates to supply most of the CESF system equipment, install the aboveground interconnecting piping (see Appendix A), and start up and operate the CESF system.

The second contractor will install the new storm drain piping associated with the offsite North Lateral reroute and will complete the other subsurface storm drain modification work associated with the project. In addition to the plan set in Appendix B, the selected general contractor has been provided with specifications; a copy of the specifications is provided in Appendix F.

3.1.1 CONTRACTOR SELECTION

Boeing has issued a work order to Landau Associates to cover the estimated cost of CESF system purchase, construction, and system startup. The subcontract for purchase and operation and maintenance of the CESF system from the supplier has been executed. A purchase agreement has been issued to Pinnacle Manufacturing for supply of the five aboveground tanks. Currently, there are no anticipated difficulties with completing the subcontracts for this work.

The contract for the rerouting and new stormwater conveyance lines (the work associated with the plans in Appendix B), was bid out to three contractors deemed qualified by Boeing. Boeing assessed the bids and selected Glacier Environmental as best capable of completing the work. The determination of the best capable bidding contractor included consideration of factors such as crew and management experience, environmental consciousness (e.g., stormwater pollution prevention, plans for temporary erosion and sediment control, soil handling), technical approach for dewatering, and ability to meet the schedule.

3.1.2 SOIL HANDLING

The contractor has been given specific detailed directions from Boeing on how to handle and contain excavated soil, where waste soil bins can be staged, how to properly sample excavated soil for waste characterization, and criteria for potential reuse of soil onsite for backfill. Contractor requirements include development of a Temporary Erosion and Sediment Control (TESC) plan with the minimum requirements in the URS set of TESC plans, following the applicable sections of the NBF site stormwater pollution prevention plan (SWPPP), and developing/modifying a site-specific health and safety plan to match the activities of this construction work.

3.1.3 ACCESS AND PERMITTING

The City of Seattle owns the land for a portion of the NBF property where the North Lateral storm drain re-route is proposed (see Sheet C504 in Appendix A for the boundary of the property owned by the City). Boeing is actively engaged with the City in order to be granted an easement or other arrangement to allow installation of the conveyance line in this proposed alignment.

Because the work associated with the LTST is being done under an ASAOC with the EPA, Boeing is not required to apply for or to be granted construction permits from state or local agencies. However, Boeing is required to meet the relevant substantive requirements of applicable regulations. A listing of the permits that might normally apply to this type of construction project, and associated relevant substantive requirements, are listed below:

- **Grade and Fill Permit** – Applicable for installation of new storm drain piping and manholes, including a State Environmental Policy Act (SEPA) checklist for excavation of more than 500 cubic yards of soil. Boeing will not apply for or obtain this permit from King County or the City, but Boeing will comply with the substantive requirements of the permit [i.e., will follow the applicable City and King County standards for stormwater conveyance design and will submit 100% design drawings and record (as-built) drawings to the City and King County].
- **Land Use Permit** – May apply to installation of tanks, pumps, and other large equipment in land area not formerly used for such equipment (will comply with the substantive requirements of the permit such as noise ordinances, traffic safety).
- **Side Sewer Permit** – Applicable to modifications of storm drain structures. The side sewer permit process is a method that the City can keep accurate records of storm drain utilities. Similar to what is stated above for the grade and fill permit, Boeing will not obtain the permit(s) but will follow the applicable City and King County standards for stormwater conveyance design and will submit 100% design drawings and record (as-built) drawings to the City and King County, so that they can update their utility records, as appropriate.
- **Construction Stormwater Permit** – Not applicable because less than 1 acre will be disturbed. However, Boeing and its contractor will comply with Best Management Practices applicable to Ecology's Construction Stormwater General Permit and with the requirements for TESC in its existing SWPPP under the Industrial Stormwater General Permit.

- **Electrical Permit** – Electrical permits through Washington State are applicable to the new electrical service lines to be installed. Because acquiring electrical permits should not cause a significant delay to the project, and because of the desire to avoid any electrical safety problems, Boeing plans to obtain all necessary electrical permits through its contractor for power supplies installed for the CESF system and associated pumps and equipment.
- **Federal Aviation Administration (FAA) Permit** – Applicable when any structures or equipment exceeds specified height restrictions within a certain distance from the airport runway. The construction work may use excavators that could exceed those height restrictions. If construction or permanent installations have the potential to exceed FAA height restrictions, Boeing will share construction plans with the FAA to ensure that its substantive requirements are met. Boeing also submitted a Notice of Proposed Construction or Alteration (FAA Form 7460-1) to King County on June 16, 2011.

3.2 PROJECT SCHEDULE

A Gantt chart showing the current estimated project schedule is shown on Figure 6.

4.0 USE OF THIS REPORT

This report has been prepared for the exclusive use of The Boeing Company and applicable regulatory agencies for specific application to the installation of a long-term stormwater treatment facility for removal of polychlorinated biphenyls from stormwater in the storm drain system at North Boeing Field. No other party is entitled to rely on the information, conclusions, and recommendations included in this document without the express written consent of Landau Associates. Further, the reuse of information, conclusions, and recommendations provided herein for extensions of the project or for any other project, without review and authorization by Landau Associates, shall be at the user's sole risk. Landau Associates warrants that within the limitations of scope, schedule, and budget, our services have been provided in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions as this project. We make no other warranty, either express or implied.

This document has been prepared under the supervision and direction of the following key staff.

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Principal

JAK/ccy/tam

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5.0 REFERENCES

AMEC Geomatrix. 2011. *Slip 4 Salinity Monitoring Data Report, North Boeing Field, Seattle/Tukwila, Washington*. Submitted to The Boeing Company. June.

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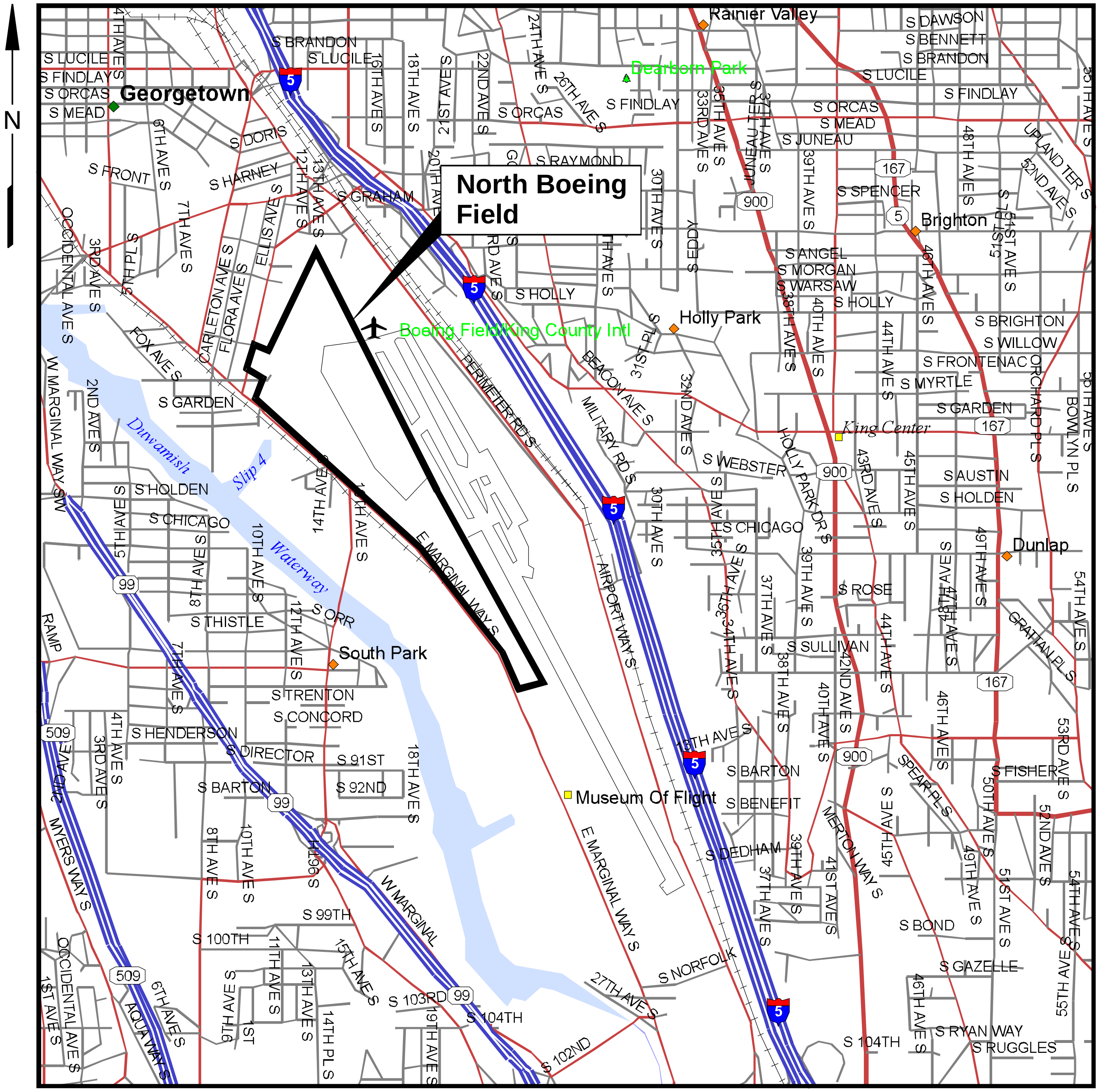

Map from DeLorme Street Atlas USA, 2002

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Scale in Miles

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North Boeing Field Seattle, Washington	**Vicinity Map**	Figure 1

Legend

Sediment Trap	North Lateral Drain Line
Lift Station Sampling Point	North-Central Lateral Drain Line
NBF Storm Drain Structures	South-Central Lateral Drain Line
Manhole 130A	South Lateral Drain Line
Long-Term Stormwater Treatment Facility	Drainage from Building 3-380 Area
New Storm Drain	Drainage from Parking Lot Area

Data Source: SAIC

0 160 320

Scale in Feet

Note

1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

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North Boeing Field
Seattle, Washington

LTST Facility Location and Storm Drain Conveyance

Figure
2

Y:\Projects\025082\MapDocs\311\90% Design Report\Fig-2-SamplingLocations.mxd 6/23/2011 NAD 1983 StatePlane Washington North FIPS 4601 Feet

Y:\Projects\025082\MapDocs\311\Fig3-On_Offsite_Basins.mxd NAD 1983 StatePlane Washington North FIPS 4601 Feet

North Boeing Field Stormwater Drainage Basin Areas	Onsite Area (Acres)	Offsite Area (Acres)	Total Area (Acres)
North Lateral (Excluding Steam Plant Area)	18.1	37.0	55.1
North Lateral Steam Plant Only - No Roof	0.0	4.1	4.1
North-Central Lateral	14.7	42.6	57.3
South-Central Lateral	21.9	42.7	64.6
South Lateral	46.3	64.3	110.6
Bldg 3-380 Area	4.6	0.0	4.6
Re-Routed to Lift Station (LS431)	0.5	0.0	0.5
Total Drainage Area to Lift Station (LS431)	106.1	190.7	296.8
Parking Lot Area (Downstream of KC Lift Station)	6.8	0.0	6.8
Sanitary Sewer <0.1 Acres			

Legend

- Off-site
- Drainage to Sanitary Sewer
- Building 3-380 Area
- North-Central Lateral
- North Lateral
- Parking Lot Area (Downstream of King County Lift Station, LS431)
- South-Central Lateral
- South Lateral
- Area Re-Routed to Lift Station LS431

0 450 900

Scale in Feet

Data Source: Aerial - SAIC 2009; Conveyance System - The Boeing Company (On-site) and SAIC 2009 (Off-site); Basin Boundaries - The Boeing Company (On-site), SAIC 2009 (Off-site) Figure 2-1 "Storm Drain Lines in the Vicinity of NBF-GTSP Site", and City of Seattle Map "Lower Duwamish Waterway Areas Draining to Slip 4"

Note

1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

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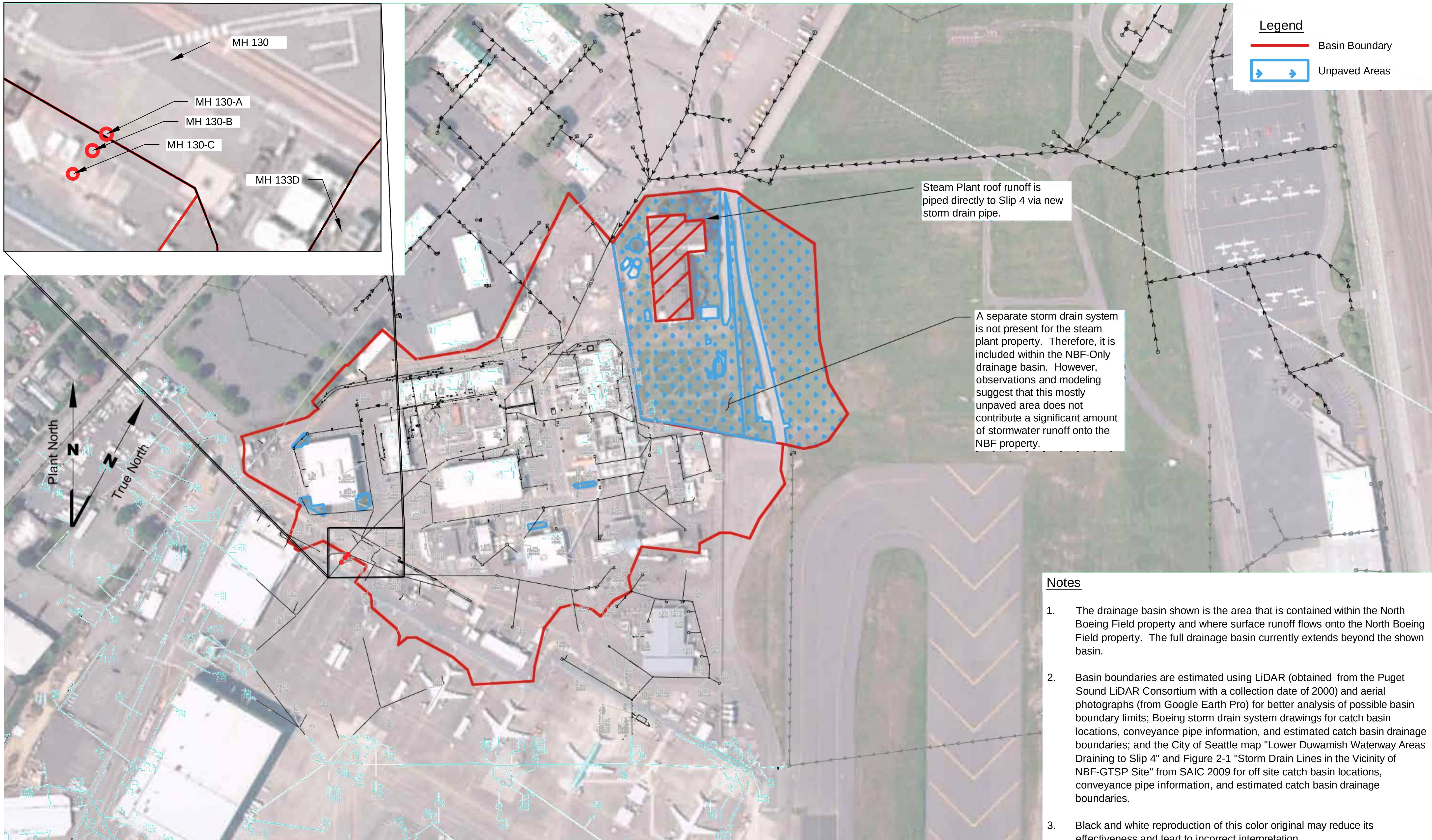
North Boeing Field
Seattle, Washington

North Boeing Field
Stormwater Drainage Basins

Figure
3



Notes

1. The drainage basin shown is the area that is contained within the North Boeing Field property and where surface runoff flows onto the North Boeing Field property. The full drainage basin currently extends beyond the shown basin.

2. Basin boundaries are estimated using LiDAR (obtained from the Puget Sound LiDAR Consortium with a collection date of 2000) and aerial photographs (from Google Earth Pro) for better analysis of possible basin boundary limits; Boeing storm drain system drawings for catch basin locations, conveyance pipe information, and estimated catch basin drainage boundaries; and the City of Seattle map "Lower Duwamish Waterway Areas Draining to Slip 4" and Figure 2-1 "Storm Drain Lines in the Vicinity of NBF-GTSP Site" from SAIC 2009 for off site catch basin locations, conveyance pipe information, and estimated catch basin drainage boundaries.

3. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Base map source: The Boeing Company 2009, Aerial Photo: SAIC 2009

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Scale in Feet

LANDAU ASSOCIATES, INC. | V:\025\082\210\004 design\F-WP-FINAL-FIG07-STORM-BASINSHJA.DWG (A) "Figure 4" 5/2/2011

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North Boeing Field
Seattle, Washington

NBF- Onsite Drainage Basin for MH 130A

Figure
4

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LANDAU ASSOCIATES, INC. | V:\025\082\311\Figure 5- OrgChart.dwg (A) "Figure 5" 5/27/2011

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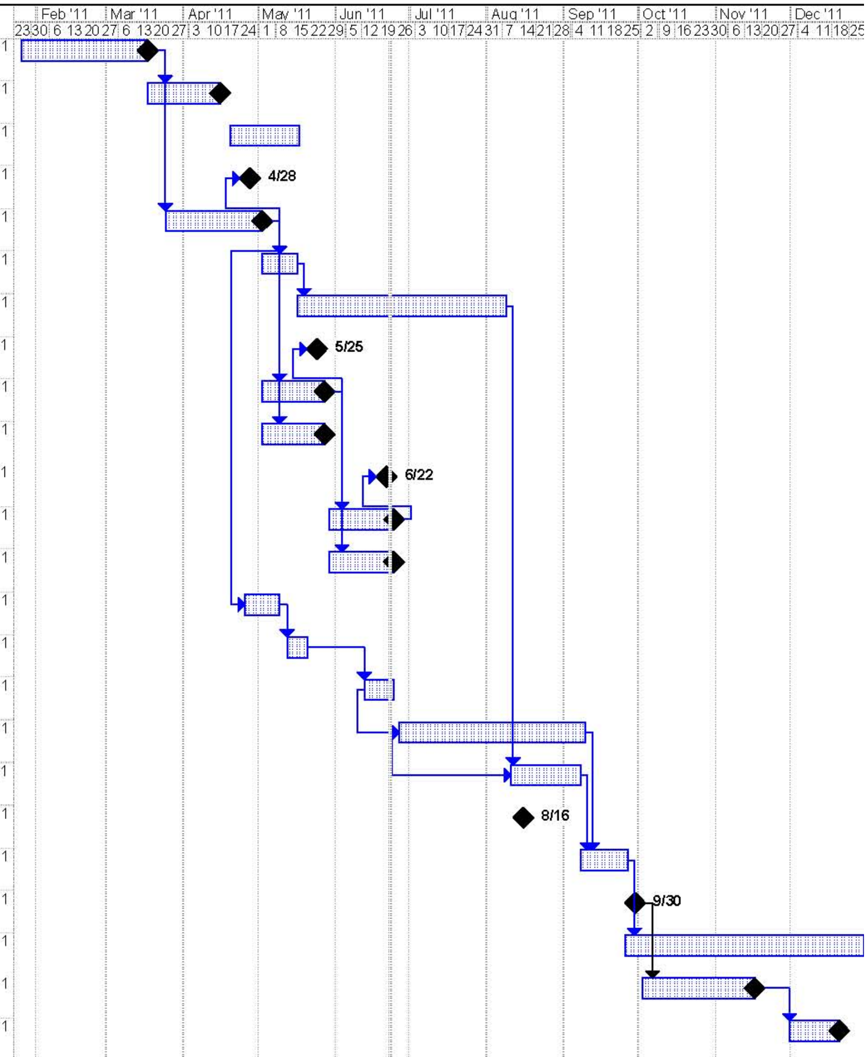
North Boeing Field
Seattle, Washington

Project Organization Chart for Long-Term Stormwater Treatment

Figure 5

ID	Task Name	Duration	Start	Finish
1	Task 3A.1. Draft Pre-Design Technical Memorandum	37 days	Wed 1/26/11	Thu 3/17/11
2	Task 3A.1. Final Pre-Design Technical Memorandum	21 days	Fri 3/18/11	Fri 4/15/11
3	Salinity Monitoring Data Technical Memo (following receipt of final data)	4 wks	Wed 4/20/11	Tue 5/17/11
4	EPA Design Review Meeting	0 days	Thu 4/28/11	Thu 4/28/11
5	Task 3.A.2 Pre-Final (60%) Design	27 days	Fri 3/25/11	Mon 5/2/11
6	Procurement of Major CESF System Components	10 days	Tue 5/3/11	Mon 5/16/11
7	Fabrication and Delivery of Major CESF System Components	12 wks	Tue 5/17/11	Mon 8/8/11
8	EPA Design Review Meeting #2 (tentative)	0 days	Wed 5/25/11	Wed 5/25/11
9	Task 3A.3. 90% Design	19 days	Tue 5/3/11	Fri 5/27/11
10	Task 3B. Draft O&M Manual	19 days	Tue 5/3/11	Fri 5/27/11
11	EPA Design Review Meeting #3 (tentative)	0 days	Wed 6/22/11	Wed 6/22/11
12	Task 3A.4. 100% Design	20 days	Mon 5/30/11	Fri 6/24/11
13	Task 3B. Final O&M Manual	20 days	Mon 5/30/11	Fri 6/24/11
14	Prepare and Release Bid Documents	10 days	Tue 4/26/11	Mon 5/9/11
15	Review Bids and Select Contractor	6 days	Fri 5/13/11	Fri 5/20/11
16	Contractor Initial Material Procurement and Mobilization	10 days	Mon 6/13/11	Fri 6/24/11
17	Construction, Subsurface Work (including material delivery/installation)	11 wks	Mon 6/27/11	Fri 9/9/11
18	CESF System Equipment Placement and Aboveground Piping	4 wks	Thu 8/11/11	Wed 9/7/11
19	EPA Project Status Meeting (tentative)	0 days	Tue 8/16/11	Tue 8/16/11
20	Startup Testing	13 days	Thu 9/8/11	Mon 9/26/11
21	Long-Term Stormwater Treatment Installed and Operating	0 days	Fri 9/30/11	Fri 9/30/11
22	CESF System Routine Operation and Maintenance	14 wks	Mon 9/26/11	Fri 12/30/11
23	Task 4. Draft Removal Action/Stormwater Treatment Completion Report	45 edays	Mon 10/3/11	Thu 11/17/11
24	Task 4. Final Completion Report (20 days after EPA comments on the draft)*	20 edays	Wed 11/30/11	Tue 12/20/11



* Deliverable date dependent on EPA review time.
Assume 2 week EPA review for deliverables.

Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

North Boeing Field
Seattle, Washington

Project Schedule for
Long-Term Stormwater Treatment

Figure
6

LANDAU ASSOCIATES

APPENDIX A

100% Design Plans for the Long-Term Stormwater Treatment System

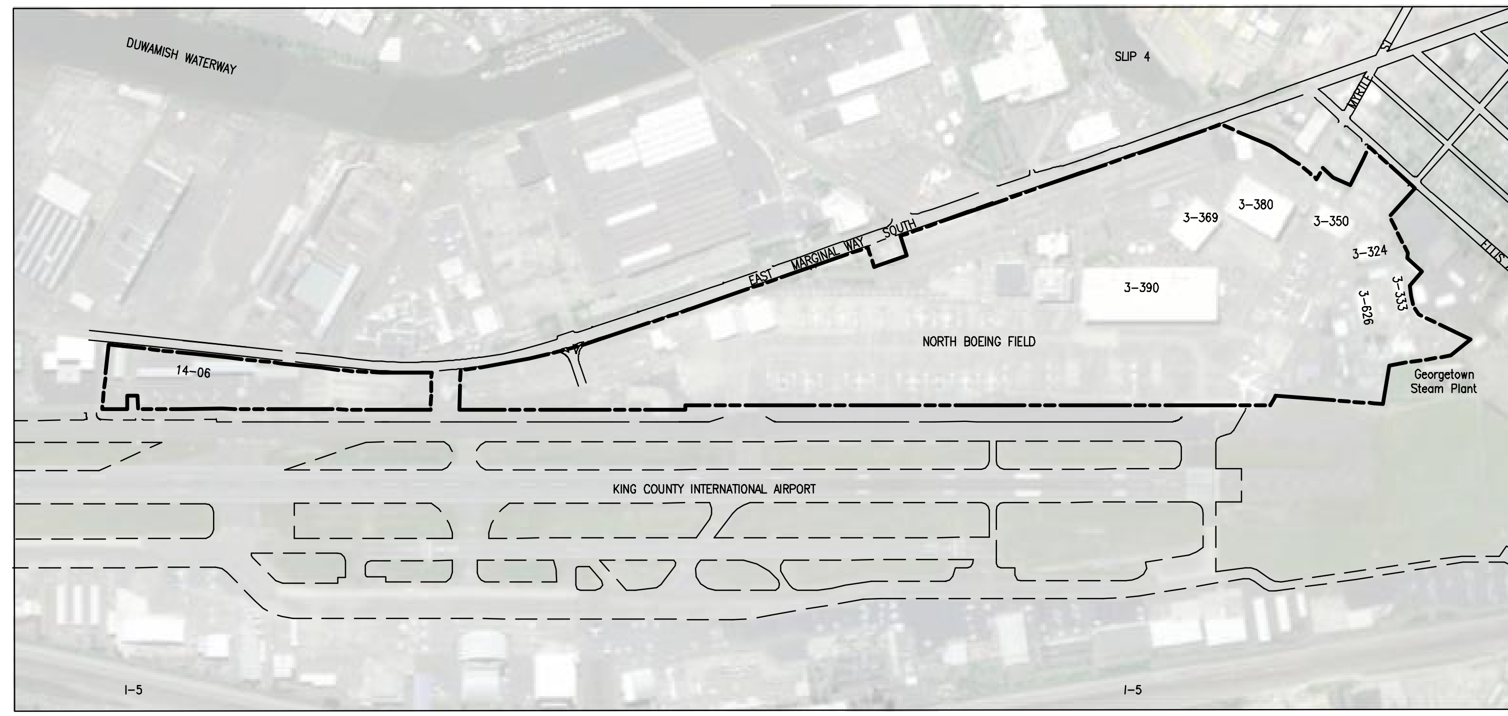
NORTH BOEING FIELD
LONG–TERM STORMWATER TREATMENT SYSTEM
LOWER DUWAMISH WATERWAY SUPERFUND SITE

EPA DOCKET NO. CERCLA–10–2010–0242

SEATTLE, WASHINGTON

VICINITY MAP

SCALE: N.T.S.



SITE MAP

SCALE: 1" = 500'

DRAWING LIST

SHEET NO.	TITLE
G101	COVER SHEET
G102	ONSITE AND OFFSITE DRAINAGE BASIN MAP
C504	STORMWATER CONVEYANCE, PLAN VIEW
C505	TREATMENT SYSTEM, PLAN VIEW
C506	STORM DRAIN MODIFICATIONS, PLAN VIEW
M502	TREATMENT SYSTEM PIPING LAYOUT, PLAN VIEW
M503	TREATMENT SYSTEM PIPING SECTIONS
M504	TREATMENT SYSTEM PIPING DETAILS
M505	TREATMENT SYSTEM TANK DETAILS
K500	PIPING AND INSTRUMENTATION LEGEND, NOTES AND DETAILS
K501	PIPING AND INSTRUMENTATION DIAGRAM STORMWATER COLLECTION AND STORAGE
K502	PIPING AND INSTRUMENTATION DIAGRAM STORMWATER TREATMENT AND DISCHARGE
K503	STORMWATER TREATMENT PROCESS FLOW DIAGRAM

PROJECT INFORMATION

SITE ADDRESS
7370 EAST MARGINAL WAY SOUTH
SEATTLE, WASHINGTON

REGULATORY LEAD
U.S. EPA REGION 10
1200 SIXTH AVENUE
SUITE 900
SEATTLE, WASHINGTON
MS. KAREN KEELEY
(206) 553–2141

OWNER
THE BOEING COMPANY
MR. CARL BACH
(206) 898–0438

ENGINEER
LANDAU ASSOCIATES, INC.
130 2ND AVENUE SOUTH
EDMONDS, WASHINGTON 98020
MR. JOE KALMAR
(425) 778–0907

LANDAU ASSOCIATES
130 2ND AVENUE S.
EDMONDS, WA. 98020
(425) 778–0907, FAX (425) 778–6409

500' 250' 0 500' 1000'
SCALE IN FEET

SYM	REVISION	BY	APPROVED	DATE	SYM	REVISION	BY	APPROVED	DATE
1	PRE–FINAL DESIGN (60%)	LANDAU	KALMAR	05.02.2011					
2	90% DESIGN	LANDAU	KALMAR	05.27.2011					
3	100% DESIGN	LANDAU	KALMAR	06.23.2011					

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ENGINEER R. LUDWIG	06.23.2011
CHECKED	
APPROVED J.KALMAR	
APPROVED	

SUBTITLE: LONG-TERM STORMWATER TREATMENT SYSTEM

TITLE: COVER SHEET

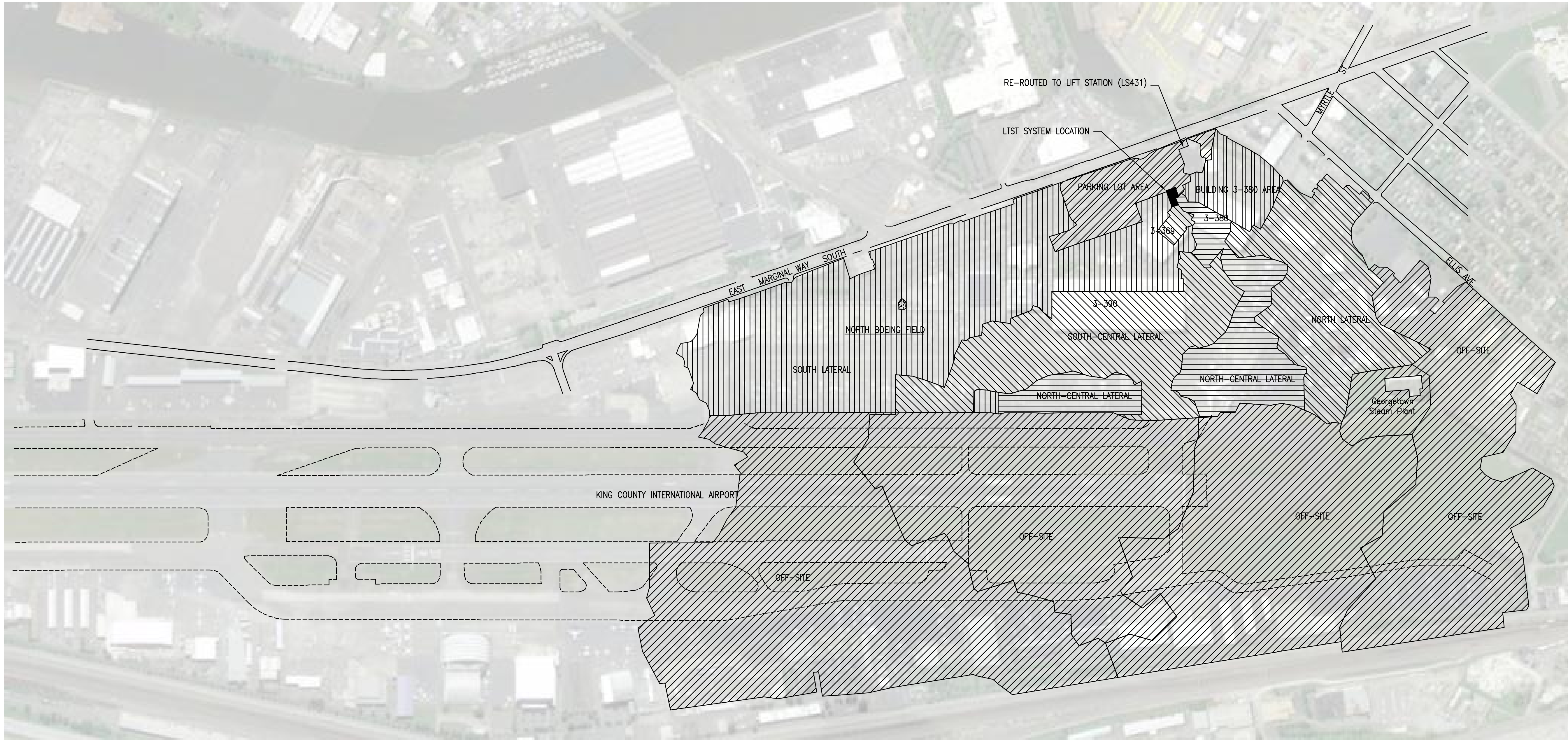
CIVIL MASTER COL. NBF

CURRENT REVISION | SYMBOL D | DATE 06.23.2011

SHEET G101

JOB NO. | COMP NO.

DWG NO. 3–YD–G101.DWG



DRAINAGE BASIN MAP

SCALE: 1" = 300'

LEGEND

- OFF-SITE
- DRAINAGE TO SANITARY SEWER
- BUILDING 3-380 AREA
- NORTH-CENTRAL LATERAL
- RE-ROUTED TO LIFT STATION (LS431)
- NORTH LATERAL
- PARKING LOT AREA (DOWNSTREAM OF KING COUNTY LIFT STATION, LS431)
- SOUTH-CENTRAL LATERAL
- SOUTH LATERAL

NORTH BOEING FIELD STORMWATER DRAINAGE BASIN AREAS	ONSITE AREA (ACRES)	OFFSITE AREA (ACRES)	TOTAL AREA (ACRES)
NORTH LATERAL (EXCLUDING STEAM PLANT AREA)	18.1	37.0	55.1
NORTH LATERAL STEAM PLANT ONLY – NO ROOF	0.0	4.1	4.1
NORTH-CENTRAL LATERAL	14.7	42.6	57.3
SOUTH-CENTRAL LATERAL	21.9	42.7	64.6
SOUTH LATERAL	46.3	64.3	110.6
BUILDING 3-380 AREA	4.6	0.0	4.6
RE-ROUTED TO LIFT STATION (LS431)	0.5	0.0	0.5
TOTAL DRAINAGE AREA TO LIFT STATION (LS431)	106.1	190.7	296.7
PARKING LOT AREA (DOWNSTREAM OF KC LIFT STATION)	6.3	0.0	6.3
SANITARY SEWER <0.1 ACRES			
GEORGETOWN STEAM PLANT ROOF = 0.5 ACRES			

300' 150' 0 300' 500'
SCALE IN FEET

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APPROVED		

SUBTITLE: LONG-TERM STORMWATER TREATMENT SYSTEM

TITLE: ONSITE AND OFFSITE DRAINAGE BASIN MAP

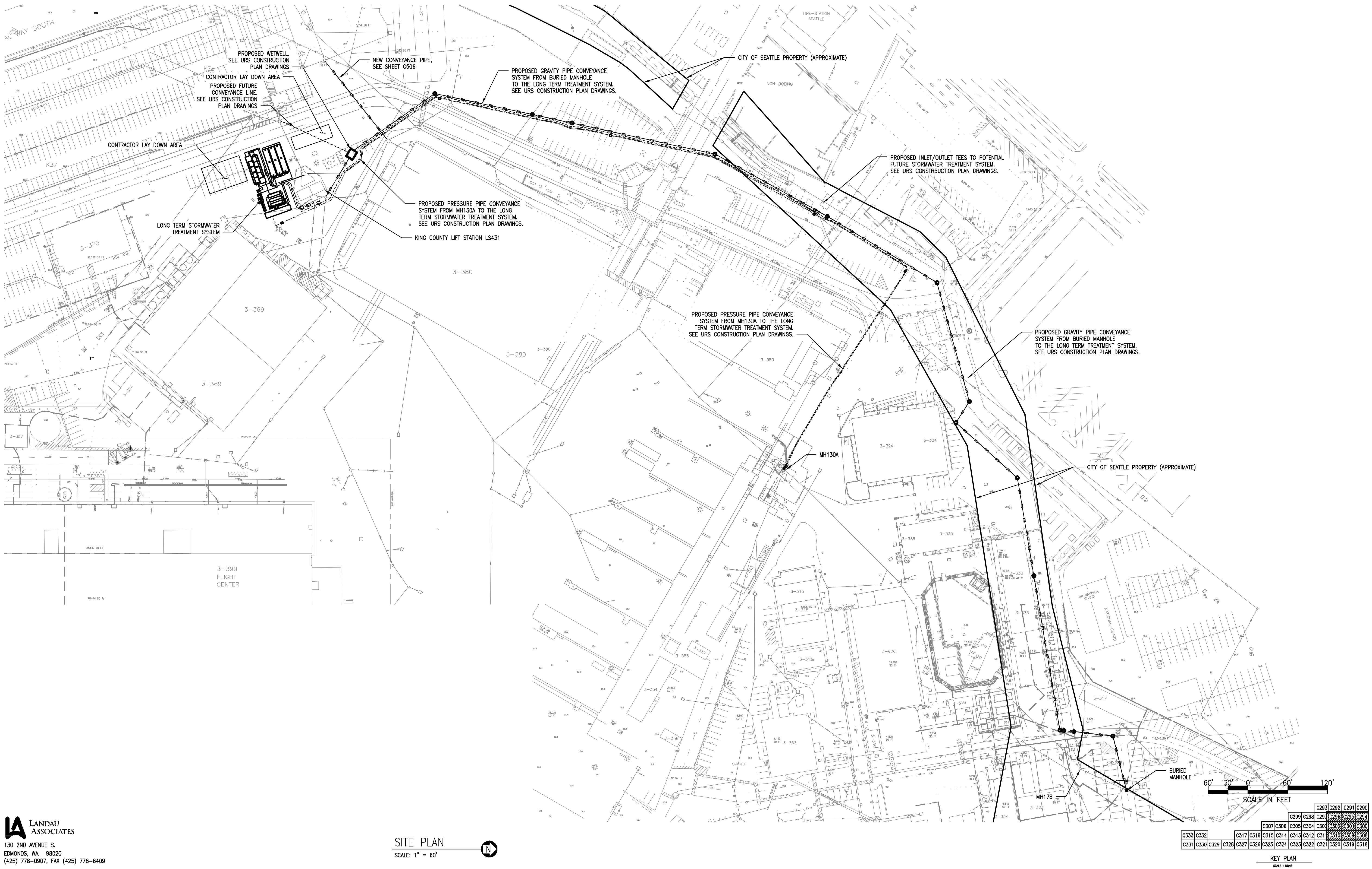
CIVIL MASTER COL. NBF

CURRENT REVISION SYMBOL D DATE 06.23.2011

SHEET G102

JOB NO. COMP NO.

DWG NO. 3-YD-G102.DWG



LANDAU ASSOCIATES

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SITE PLAN

SCALE: 1" = 60'

SYM	REVISION	BY	APPROVED	DATE	SYM	REVISION	BY	APPROVED	DATE
1	PRE-FINAL DESIGN (60%)	LANDAU	KALMAR	05.02.2011					
2	90% DESIGN	LANDAU	KALMAR	02.27.2011					
3	100% DESIGN	LANDAU	KALMAR	06.23.2011					

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APPROVED		

SUBTITLE: LONG-TERM STORMWATER TREATMENT SYSTEM

TITLE: STORMWATER CONVEYANCE PLAN VIEW

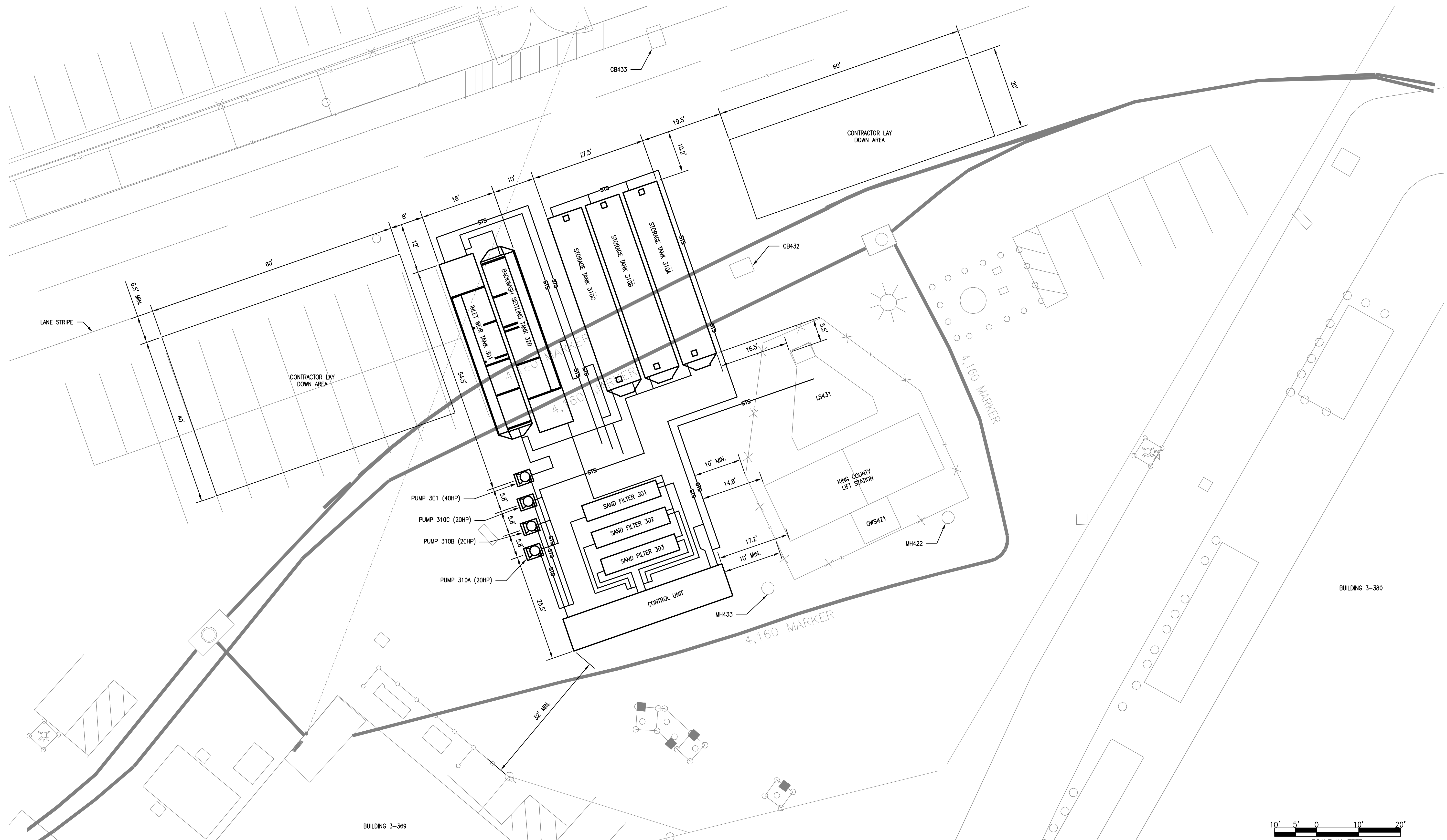
CIVIL MASTER COL. NBF

CURRENT REVISION SYMBOL D DATE 06.23.2011

SHEET C504

JOB NO. COMP NO.

DWG NO. 3-YD-C504.DWG



									C293	C292	C291	C290
							C299	C298	C297	C296	C295	C294
					C307	C306	C305	C304	C303	C302	C301	C300
C332			C317	C316	C315	C314	C313	C312	C311	C310	C309	C308
C330	C329	C328	C327	C326	C325	C324	C323	C322	C321	C320	C319	C318

KEY PLAN
SCALE : NONE

LANDAU ASSOCIATES
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SITE PLAN
SCALE: 1" = 10'

SYM	REVISION	BY	APPROVED	DATE	SYM	REVISION	BY	APPROVED	DATE
1	PRE-FINAL DESIGN (60%)	LANDAU	KALMAR	05.02.2011					
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3	100% DESIGN	LANDAU	KALMAR	06.23.2011					

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SUBTITLE
LONG-TERM STORMWATER TREATMENT SYSTEM

TITLE
TREATMENT SYSTEM
PLAN VIEW

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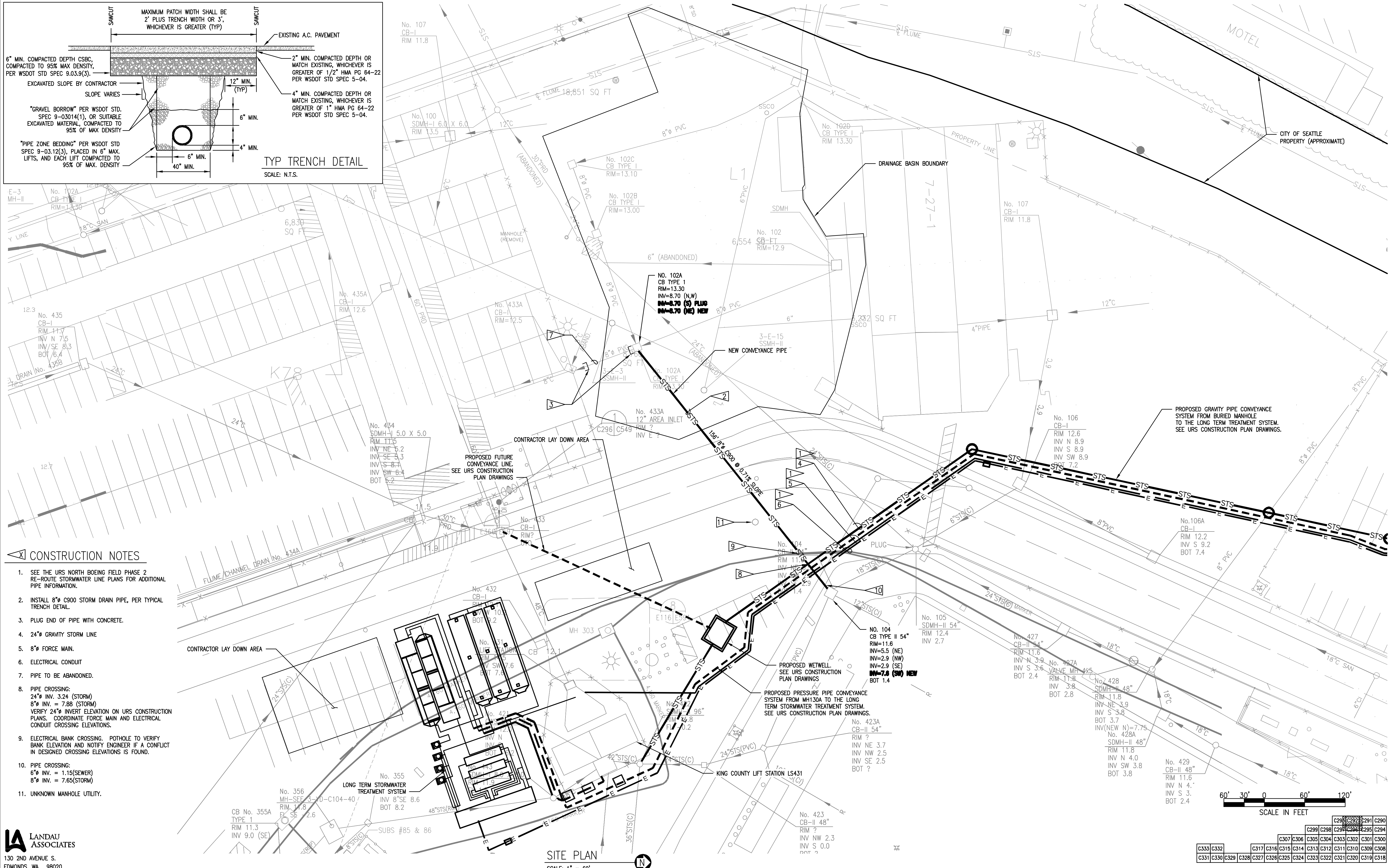
SHEET C505

JOB NO. | COMP NO.

DWG NO. 3-YD-C505.DWG



CONSTRUCTION NOTES

1. SEE THE URS NORTH BOEING FIELD PHASE 2 RE-ROUTE STORMWATER LINE PLANS FOR ADDITIONAL PIPE INFORMATION.
2. INSTALL 8"ø C900 STORM DRAIN PIPE, PER TYPICAL TRENCH DETAIL.
3. PLUG END OF PIPE WITH CONCRETE.
4. 24"ø GRAVITY STORM LINE
5. 8"ø FORCE MAIN.
6. ELECTRICAL CONDUIT
7. PIPE TO BE ABANDONED.
8. PIPE CROSSING:
   24"ø INV. 3.24 (STORM)
   8"ø INV. = 7.88 (STORM)
   VERIFY 24"ø INVERT ELEVATION ON URS CONSTRUCTION PLANS. COORDINATE FORCE MAIN AND ELECTRICAL CONDUIT CROSSING ELEVATIONS.
9. ELECTRICAL BANK CROSSING. POTHOLE TO VERIFY BANK ELEVATION AND NOTIFY ENGINEER IF A CONFLICT IN DESIGNED CROSSING ELEVATIONS IS FOUND.
10. PIPE CROSSING:
    6"ø INV. = 1.15(SEWER)
    8"ø INV. = 7.65(STORM)
11. UNKNOWN MANHOLE UTILITY.

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1	100% DESIGN	LANDAU	KALMAR	06.23.2011					

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APPROVED		

SUBTITLE: LONG-TERM STORMWATER TREATMENT SYSTEM

TITLE: STORM DRAIN MODIFICATIONS PLAN VIEW

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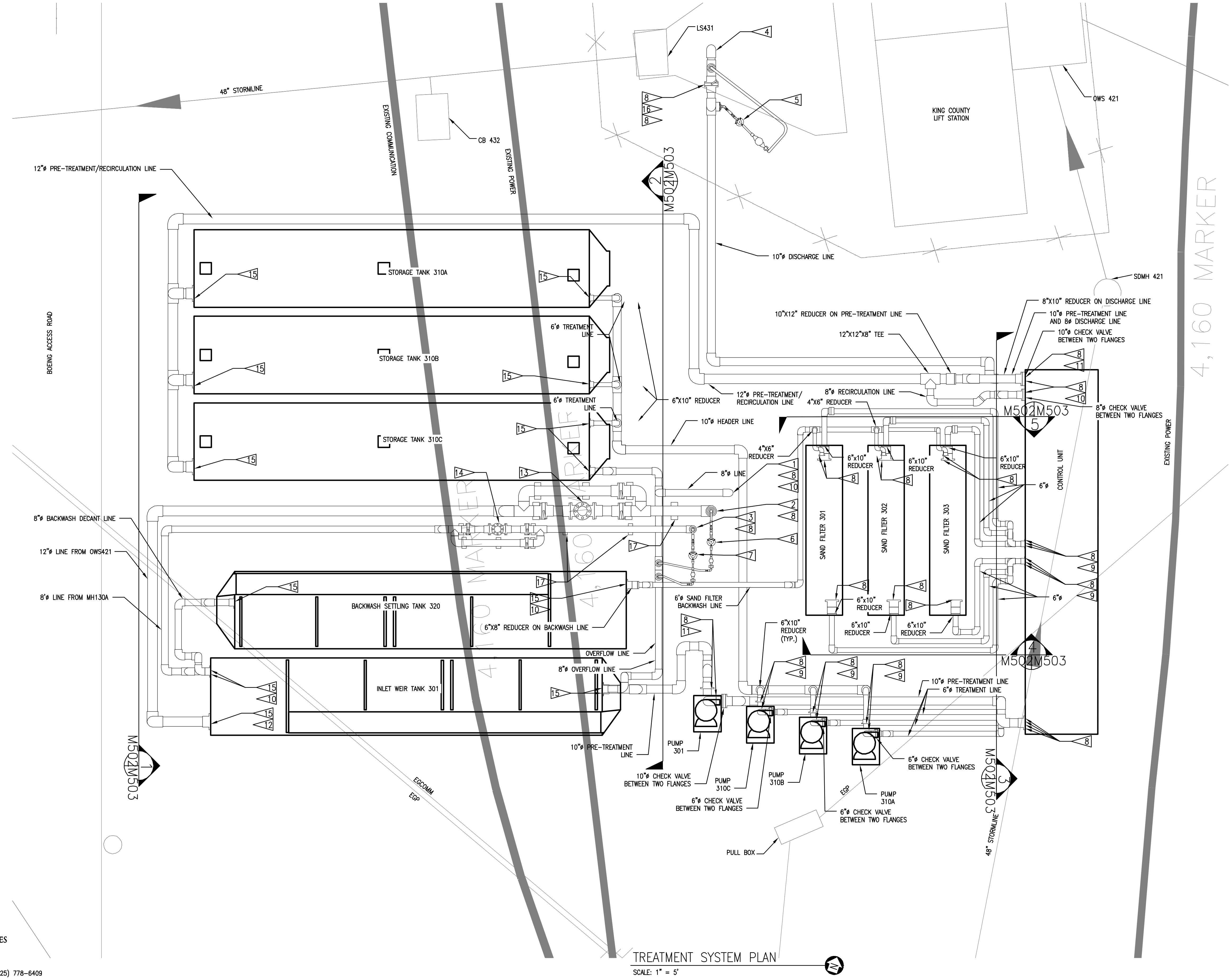
SHEET C506

JOB NO. | COMP NO.

DWG NO. 3-YD-C506.DWG



TREATMENT SYSTEM PLAN

SCALE: 1" = 5'

CONSTRUCTION NOTES

1. 8"ø OVERFLOW LINE. FLANGED PIPE CONNECTION INSTALLED BY OTHERS.
2. 8"ø PRESSURE PIPE FROM MH130A. FLANGED PIPE CONNECTION INSTALLED BY OTHERS.
3. 12"ø PRESSURE PIPE FROM OWS421. FLANGED PIPE CONNECTION INSTALLED BY OTHERS.
4. 10"ø OUTLET PIPE LOCATION. SEE DETAIL 4 M502 M504
5. EFFLUENT FILTER BAG ASSEMBLY. SEE DETAIL 1 M502 M504
6. INFLUENT OWS FILTER BAG ASSEMBLY. SEE DETAIL 2 M502 M504
7. INFLUENT MH130A FILTER BAG ASSEMBLY. SEE DETAIL 3 M502 M504
8. INSTALL FLANGED CONNECTION.
9. INSTALL 6"ø PROCO MOLDED WIDE ARCH EXPANSION JOINT MODEL NUMBER 261R, OR APPROVED EQUIVALENT, BETWEEN FLANGES.
10. INSTALL 8"ø PROCO MOLDED WIDE ARCH EXPANSION JOINT MODEL NUMBER 261R, OR APPROVED EQUIVALENT, BETWEEN FLANGES.
11. INSTALL 10"ø PROCO MOLDED WIDE ARCH EXPANSION JOINT MODEL NUMBER 261R, OR APPROVED EQUIVALENT, BETWEEN FLANGES.
12. INSTALL 12"ø PROCO MOLDED WIDE ARCH EXPANSION JOINT MODEL NUMBER 261R, OR APPROVED EQUIVALENT, BETWEEN FLANGES.
13. 12" BASKET STRAINER ASSEMBLY. SEE DETAIL 5 M502 M504
14. 8" BASKET STRAINER ASSEMBLE. SEE DETAIL 6 M502 M504
15. BUTTERFLY VALVE AND FLANGED CONNECTION SUPPLIED BY TANK MANUFACTURER.
16. INSTALL 10"ø BUTTERFLY VALVE.
17. INSTALL PIPE SUPPORT.

GENERAL NOTES

1. ALL PVC PIPE MUST BE LIGHTLY SANDED AND PAINTED WITH 100% ACRYLIC PAINT. THIS INCLUDES ALL JOINTS AFTER THEY HAVE BEEN GLUED. THE PAINT SHALL BE WHITE OR AN APPROVED LIGHT COLOR.
2. PIPE AND EQUIPMENT SHALL HAVE FREEZE PROTECTION INSTALLED. FREEZE PROTECTION INCLUDES RECIRCULATION OF WATER WITHIN THE PIPES WHEN TEMPERATURES GET BELOW FREEZING AND DRAINING SPIGOTS INSTALLED AT KEY LOCATIONS.
3. BASKET STRAINER ASSEMBLES SHALL BE PAINTED WITH 100% ACRYLIC PAINT. THIS INCLUDES ALL JOINTS AFTER THEY HAVE BEEN GLUED. THE PAINT SHALL BE WHITE OR AN APPROVED LIGHT COLOR.

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CHECKED		
APPROVED	J.KALMAR	06.23.2011
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SUBTITLE: LONG-TERM STORMWATER TREATMENT SYSTEM

TITLE: TREATMENT SYSTEM PIPING LAYOUT PLAN VIEW

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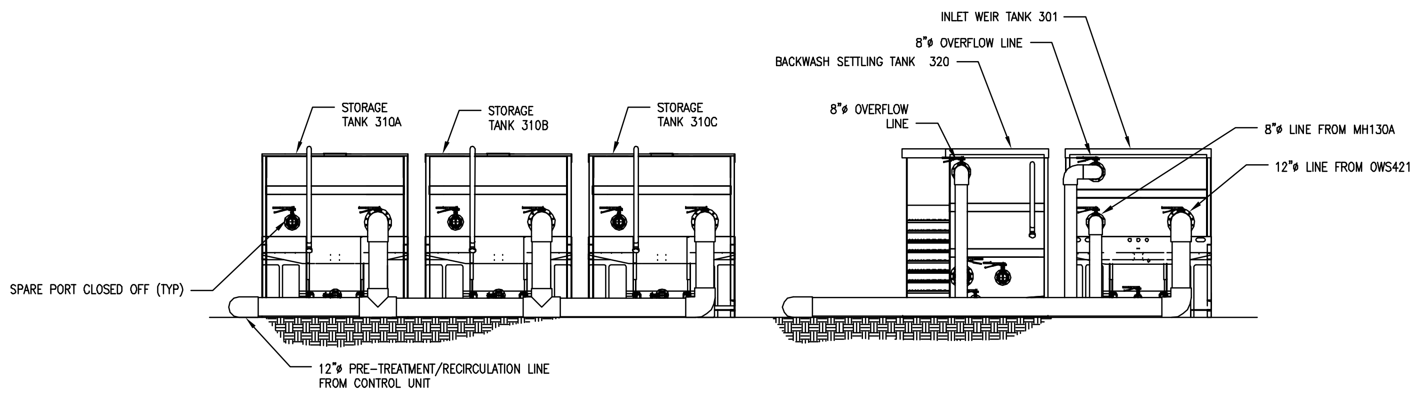
CURRENT REVISION: | SYMBOL: D | DATE: 06.23.2011

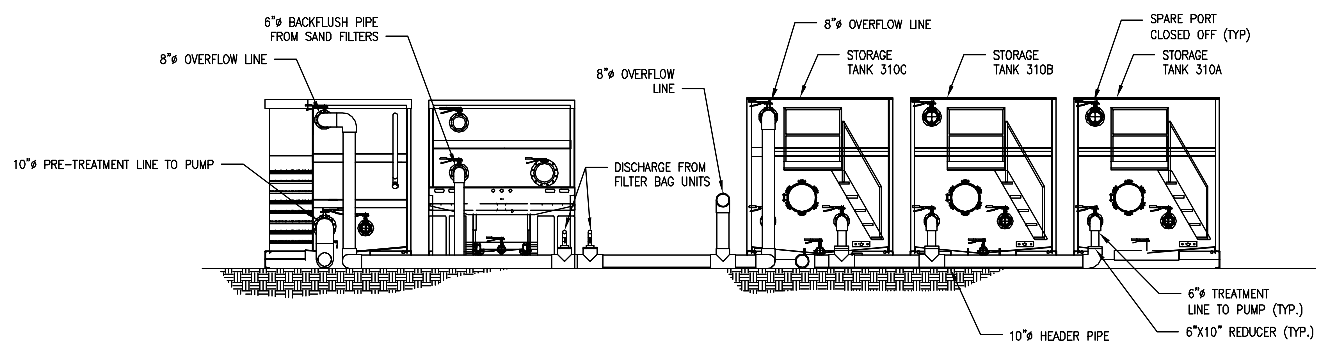
SHEET: M502

JOB NO. | COMP NO.

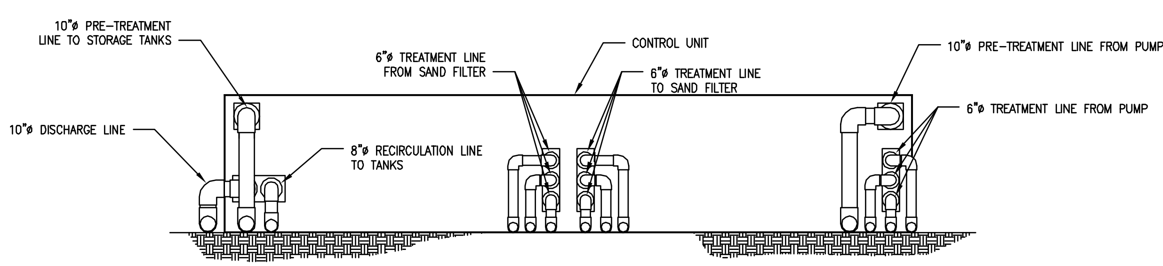
DWG NO. 3-YD-M502.DWG



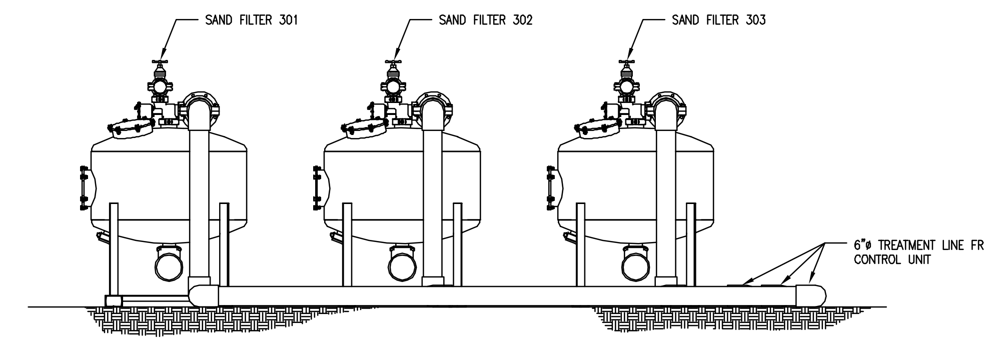
1 TANK SECTION
M502 C503 N.T.S.



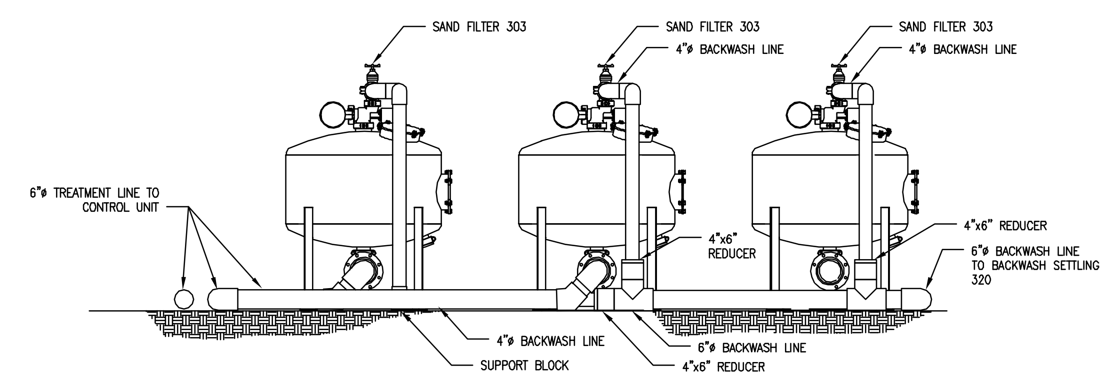
2 TANK SECTION
M502 C503 N.T.S.



3 CONTROL UNIT SECTION
M502 C503 N.T.S.



4 SAND FILTER SECTION
M502 C503 N.T.S.



5 SAND FILTER SECTION
M502 C503 N.T.S.

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3	100% DESIGN	LANDAU	KALMAR	06.23.2011					

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ENGINEER	R. LUDWIG	06.23.2011
CHECKED		
APPROVED	J.KALMAR	06.23.2011
APPROVED		

SUBTITLE: LONG-TERM STORMWATER TREATMENT SYSTEM

TITLE: TREATMENT SYSTEM PIPING SECTIONS

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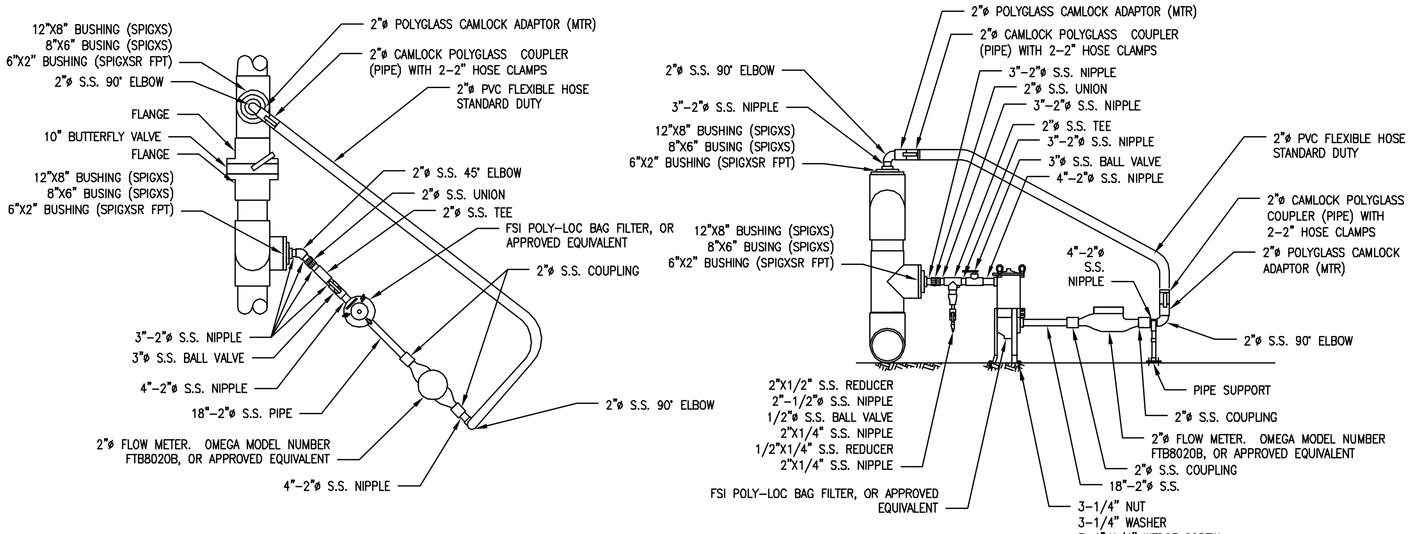
CURRENT REVISION	SYMBOL	DATE
	D	05.27.2011

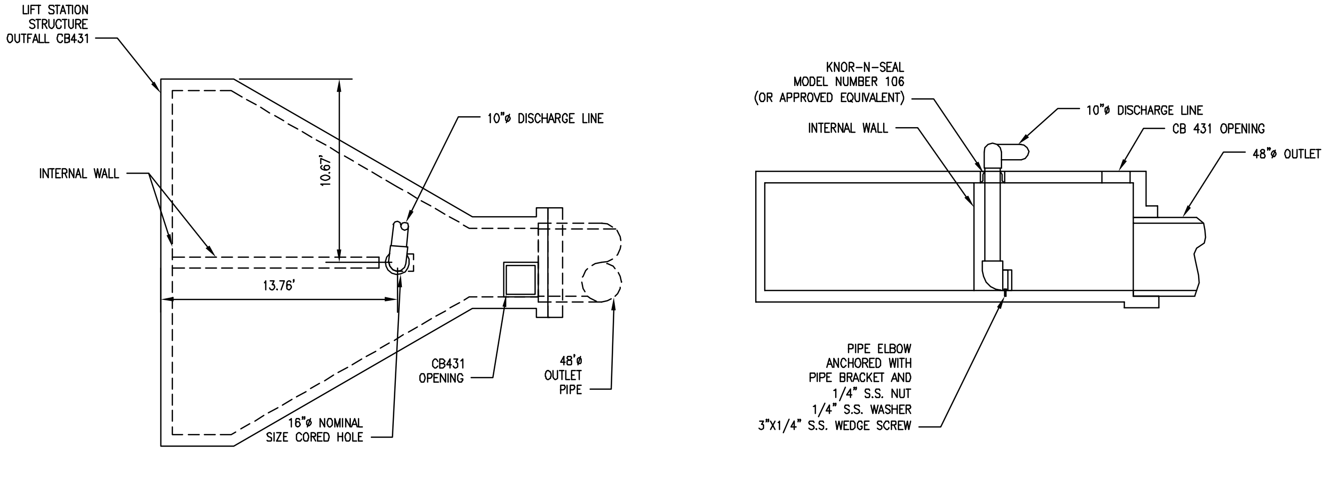
SHEET: M503

JOB NO. | COMP NO.

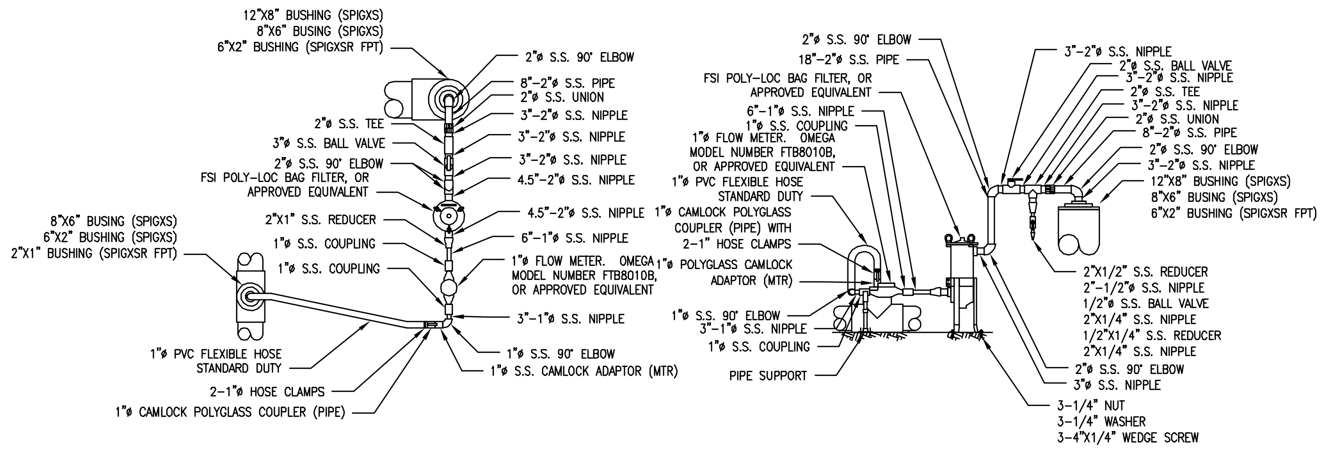
DWG NO. 3-YD-M503.DWG



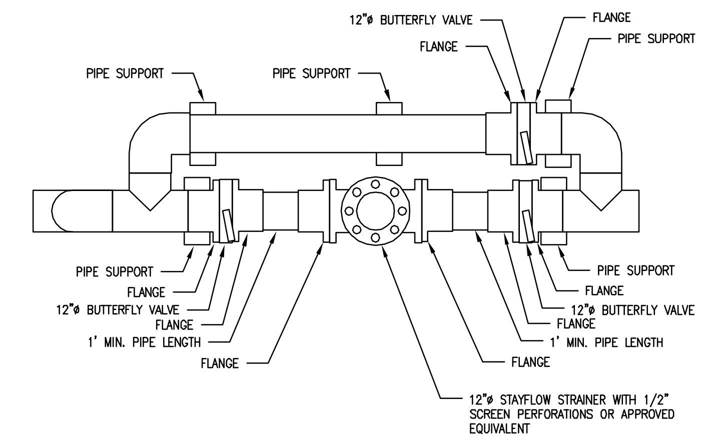
1 M502 C504 EFFLUENT FILTER DETAIL
N.T.S.



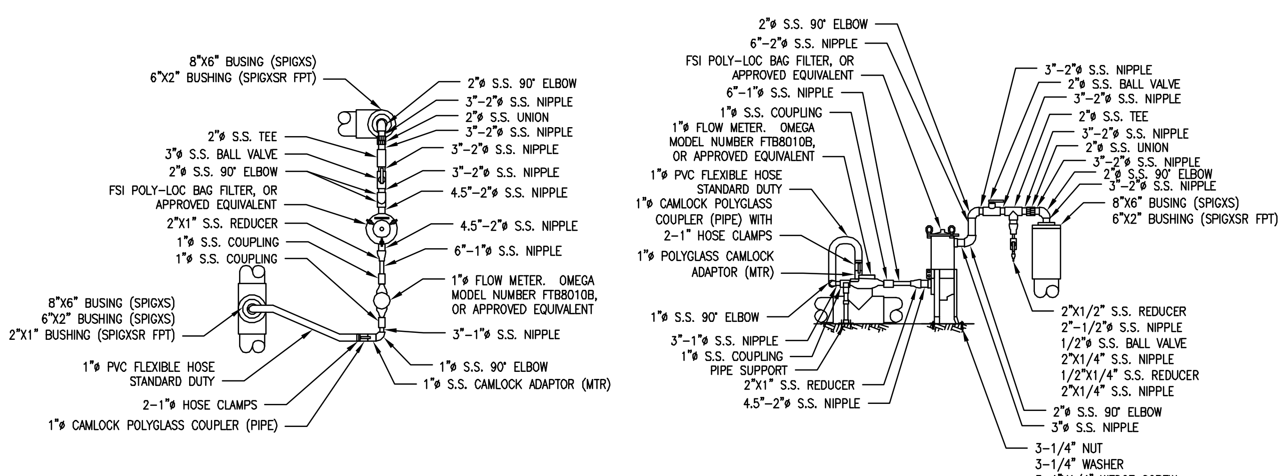
4 M502 C504 OUTLET PIPE PLAN AND PROFILE DETAIL
N.T.S.



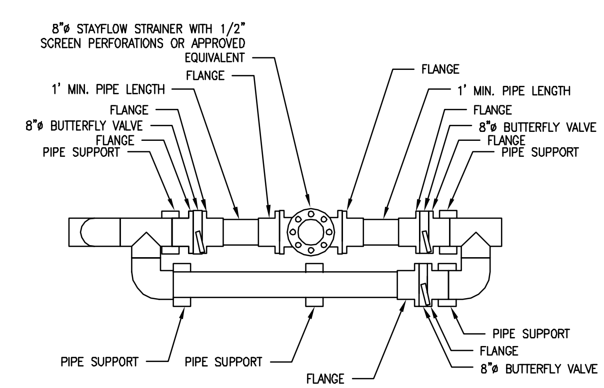
2 M502 C504 INFLUENT OWS FILTER DETAIL
N.T.S.



5 M502 C504 12"ø BASKET STRAINER DETAIL
N.T.S.



3 M502 C504 INFLUENT MH130A FILTER DETAIL
N.T.S.



6 M502 C504 8"ø BASKET STRAINER DETAIL
N.T.S.

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CHECKED		
APPROVED	J.KALMAR	06.23.2011
APPROVED		

SUBTITLE: LONG-TERM STORMWATER TREATMENT SYSTEM

TITLE: TREATMENT SYSTEM PIPING DETAILS

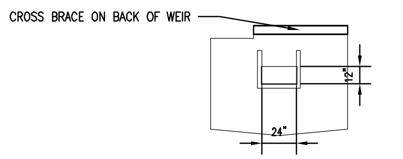
CIVIL MASTER COL. NBF

CURRENT REVISION: SYMBOL D DATE 06.23.2011

SHEET M504

JOB NO. COMP NO.

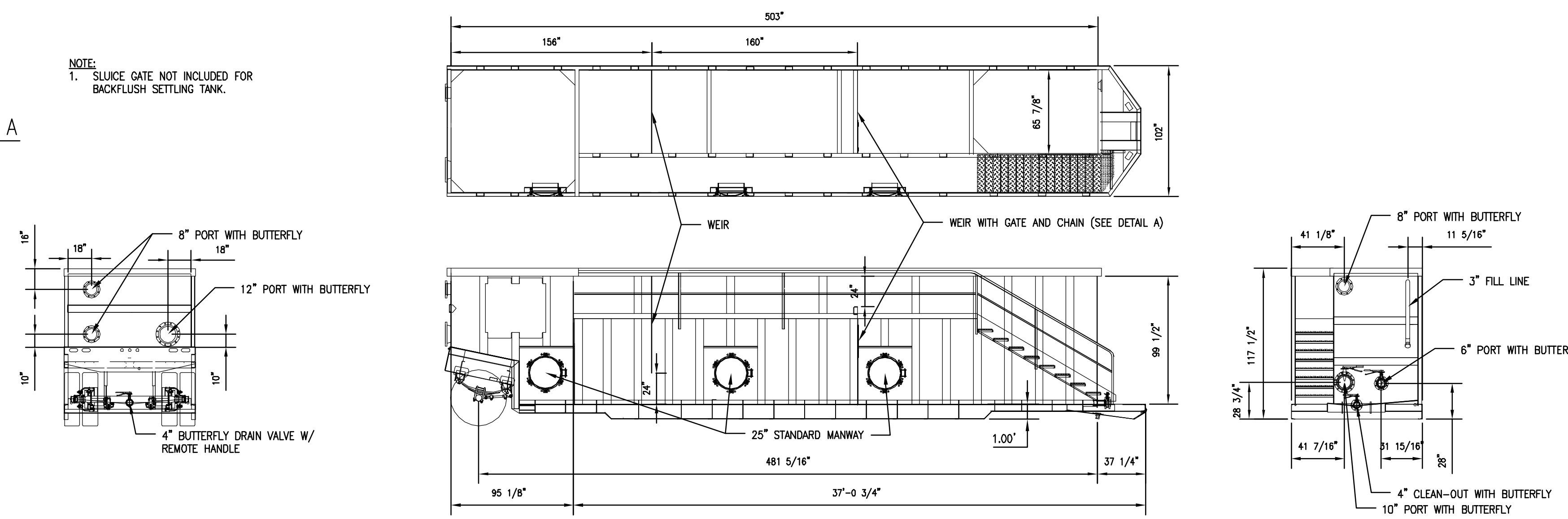
DWG NO. 3-YD-M503.DWG



NOTE:
1. SLUICE GATE NOT INCLUDED FOR BACKFLUSH SETTLING TANK.

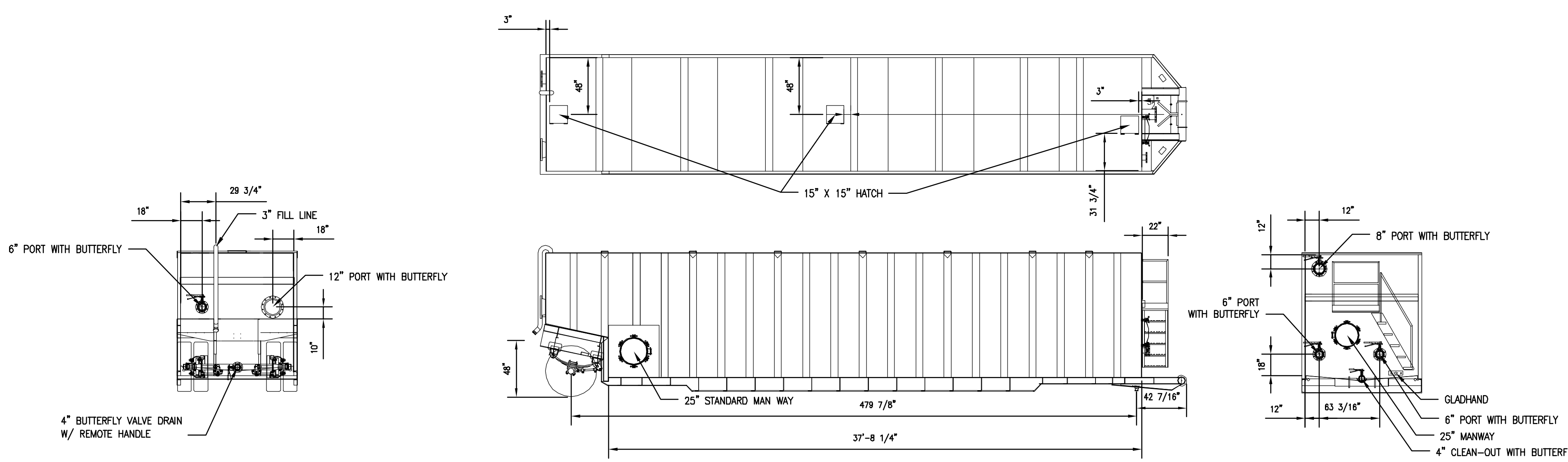
SLUICE GATE DETAIL A

SCALE: N.T.S.



WEIR TANK/BACKFLUSH SETTLING TANK DETAIL

SCALE: N.T.S.



STORAGE TANK DETAIL

SCALE: N.T.S.

SCALE IN FEET
5' 2.5' 0 5' 10'

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1	PRE-FINAL DESIGN (60%)	LANDAU	KALMAR	05.27.2011					
2	90% DESIGN	LANDAU	KALMAR	05.27.2011					
3	100% DESIGN	LANDAU	J.KALMAR	06.23.2011					

BOEING

ACCEPTABILITY
THIS DESIGN AND/OR SPECIFICATION IS APPROVED

APPROVED BY	DEPT.	DATE

DRAWN	B.TAYLOR	06.23.2011
CHECKED	J.DAVIS	06.23.2011
ENGINEER	R. LUDWIG	06.23.2011
CHECKED		
APPROVED	J.KALMAR	
APPROVED		

SUBTITLE: LONG-TERM STORMWATER TREATMENT SYSTEM

TITLE: TREATMENT SYSTEM TANK DETAILS

CIVIL MASTER COL. NBF

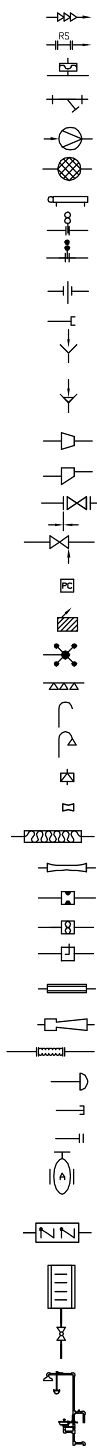
CURRENT REVISION	SYMBOL	DATE
	D	06.23.2011

SHEET: M505

JOB NO. COMP NO.

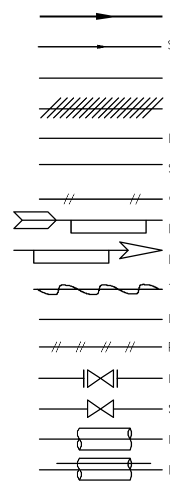
DWG NO. 3-YD-M504.DWG

PIPING SYMBOLS



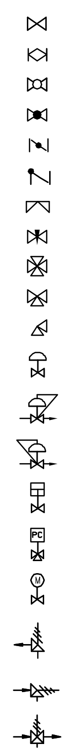
- LINE MIXER
- REMOVABLE SPOOL
- DIAPHRAGM SEAL
- "Y" TYPE STRAINER
- CONE STRAINER
- BASKET STRAINER
- THIEF HATCH
- OPEN SPECTACLE BLIND
- CLOSED SPECTACLE BLIND
- UNION
- HOSE CONNECTION
- OPEN DRAIN
- OPEN DRAIN WITH LIQUID SEAL
- CONCENTRIC REDUCER
- ECCENTRIC REDUCER
- SPECIFICATION BREAK
- LINE NUMBER CHANGE
- AUTOMATIC DUMP TRAP (STEAM TRAP)
- FIRE HOSE REEL
- FIRE HYDRANT
- FIRE SPRINKLER HEADS
- VENT TO ATMOSPHERE
- VENT WITH FLAME ARRESTOR
- RUPTURE DISC
- QUICK DISCONNECT
- FLEXIBLE COUPLING
- FLOW ELEMENT (VENTURI OR NOZZLE)
- FLOW ELEMENT (ELECTROMAGNETIC)
- FLOW ELEMENT (TURBINE METER)
- FLOW ELEMENT (PITOT TUBE)
- FLOW STRAIGHTENING VANES
- EJECTOR/EDUCTOR
- EXPANSION JOINT
- WELD CAP
- SCD. CAP
- BLIND FLANGE
- PULSATION DAMPENER
- BACKFLOW PREVENTOR
- CALIBRATION TUBE
- EMERGENCY SHOWER AND EYE WASH

LINE SYMBOLS



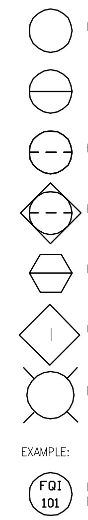
- MAIN PROCESS
- SECONDARY PROCESS
- EXISTING LINES
- LINES TO BE DISMANTLED
- FUTURE
- SKID OR PACKAGE LIMIT
- CAPILLARY TUBE
- LINES FROM (DRAWING NO. IN BOX)
- LINES TO (DRAWING NO. IN BOX)
- TELEPHONE TELEMETRY SIGNAL
- ELECTRIC SIGNAL
- PNEUMATIC SIGNAL
- FLANGED FITTINGS
- SCREWED FITTINGS
- INSULATED LINE
- INSULATED HEAT TRACED LINE

VALVE SYMBOLS



- GATE VALVE (OR MISCELLANEOUS VALVE)
- PLUG VALVE
- BALL VALVE (OR MISCELLANEOUS VALVE)
- GLOBE VALVE
- BUTTERFLY VALVE
- CHECK VALVE
- DIAPHRAGM VALVE
- NEEDLE VALVE
- FOUR-WAY VALVE
- THREE-WAY VALVE
- ANGLE VALVE
- DIAPHRAGM ACTUATED CONTROL VALVE
- PRESSURE REGULATOR (SELF CONTAINED)
- BACK PRESSURE REGULATOR (SELF CONTAINED)
- PISTON-OPERATED VALVE
- SOLENOID VALVE
- MOTORIZED VALVE
- PRESSURE RELIEF VALVE
- VACUUM RELIEF VALVE
- COMBINATION AIR/VACUUM RELIEF VALVE

INSTRUMENT SYMBOLS

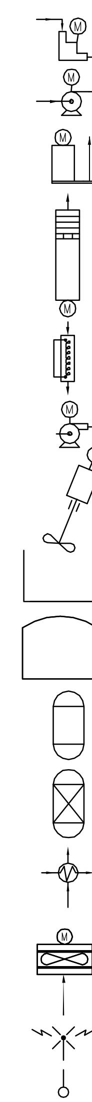


- LOCALLY MOUNTED INSTRUMENT/LOCAL DISPLAY
- CENTRAL CONTROL PANEL MOUNTED INSTRUMENT
- REAR OF PANEL MOUNTED INSTRUMENT
- FUNCTIONAL PLC
- FUNCTIONAL PROCESS COMPUTER
- UNDEFINED INTERLOCK LOGIC
- FUNCTION/ALARM LIGHT

EXAMPLE:

FQI 101 — FLOW TOTALIZING INDICATOR NO. 101

EQUIPMENT SYMBOLS



- METERING PUMP
- PUMP, CENTRIFUGAL
- ELECTRIC SUBMERSIBLE PUMP
- WELL PUMP
- INLINE DUCT HEATER
- BLOWER, w/ SILENCER
- MIXER
- TANK, OPEN
- TANK, CLOSED (NON-PRESSURE)
- PRESSURE VESSEL
- PRESSURE VESSEL WITH PACKED BED (SPECIFY BED MATERIAL)
- HEAT EXCHANGER
- EXHAUST FAN
- CELLULAR OR RADIO FREQUENCY TELEMETRY SIGNAL AND ANTENNA
- LEVEL PROBE

LINE IDENTIFICATION SYSTEM

GW101-2"-GALV-000

- LETTERS LINE IDENTIFICATION
- LINE NUMBER
- LINE SIZE
- PIPING SPECIFICATION OR PIPING ABBREVIATION
- CODE DESIGNATING INSULATION

EXAMPLE:
TWO INCH, NON-INSULATED, GALV GROUNDWATER LINE NO. 101

INSTRUMENT IDENTIFICATION TABLE

	FIRST LETTER		SUCCEEDING LETTERS		
	MEASURED OR INITIATING VARIABLE	MODIFIER	READOUT OR PASSIVE FUNCTION	OUTPUT FUNCTION	MODIFIER
A	ANALYSIS		ALARM		
B	BURNER, COMBUSTION		USER'S CHOICE	USER'S CHOICE	USER'S CHOICE
C	USER'S CHOICE			CONTROL	
D	USER'S CHOICE	DIFFERENTIAL			
E	VOLTAGE		SENSOR (PRIMARY ELEMENT)		
F	FLOW RATE	RATIO (FRACTION)			
G	GENERAL (SYSTEM)		GLASS, VIEWING DEVICE		
H	HAND				HIGH
I	CURRENT (ELECTRIC)		INDICATE		
J	POWER	SCAN			
K	TIME, TIME SCHEDULE	TIME RATE OF CHANGE		CONTROL STATION	
L	LEVEL		LIGHT		LOW
M	USER'S CHOICE	MOMENTARY			MIDDLE, INTERMEDIATE
N	TURBIDITY		USER'S CHOICE	USER'S CHOICE	USER'S CHOICE
O	USER'S CHOICE		ORIFICE, RESTRICTION		
P	PRESSURE, VACUUM		POINT (TEST) CONNECTION		
Q	QUANTITY	INTEGRATE, TOTALIZE			
R	RADIATION		RECORD		
S	SPEED, FREQUENCY	SAFETY		SWITCH	
T	TEMPERATURE			TRANSMIT	
U	MULTIVARIABLE		MULTIFUNCTION	MULTIFUNCTION	MULTIFUNCTION
V	VIBRATION, MECHANICAL ANALYSIS			VALVE, DAMPER, LOUVER	
W	WEIGHT, FORCE		WELL		
X	UNCLASSIFIED	X AXIS	UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED
Y	EVENT, STATE OR PRESENCE	Y AXIS		RELAY, COMPUTE, CONVERT	
Z	POSITION, DIMENSION	Z AXIS		DRIVER, ACTUATOR, UNCLASSIFIED FINAL CONTROL ELEMENT	

ABBREVIATIONS

LINE IDENTIFICATION LETTERS

AC	ACID
AI	INSTRUMENT AIR
AT	TREATED AIR
AU	UTILITY AIR
AV	AIR VENT
BD	BLOWDOWN
BFW	BOILER FEED WATER
BW	BACKWASH WATER
CA	CAUSTIC
CH	STEAM CONDENSATE
CW	COOLING WATER
CWR	COOLING WATER RETURN
CWS	COOLING WATER SUPPLY
DIW	DEIONIZED WATER
DR	DRAIN
DW	DRINKING (POTABLE) WATER
ELL	90° ELBOW
FG	FUEL GAS
FO	FUEL OIL
FW	FRESH WATER
FWL	FIREWATER LINE
GD	GRAVITY DRAIN
GW	GROUNDWATER
K	CHEMICAL ADDITIVE
N	NITROGEN
OD	DRY OIL
OS	OIL SLOP
O	OIL
R	REFRIGERANT
S	STEAM
SA	SODA ASH
SFW	SOFT WATER
SR	SPENT REGEN.
SS	SANITARY SEWER
SW	STORMWATER
V	VENT
VA	VACUUM
WR	RECLAIMED WATER
WT	TREATED WATER
WW	WASTE WATER

PIPING ABBREVIATIONS

ABS	ACRYLONITRILE BUTADIENE STYRENE
AC	ASBESTOS CEMENT
CI	CAST IRON
CM	CORRUGATED METAL
CPVC	CHLORINATED POLYVINYL CHLORIDE
CU	COPPER
DC	DOUBLE CONTAINMENT
DI	DUCTILE IRON
FRP	FIBERGLASS REINFORCED PLASTIC
GALV	GALVANIZED STEEL
HDPE	HIGH DENSITY POLYETHYLENE
NYL	NYLON
PP	POLYPROPYLENE
PVC	POLYVINYL CHLORIDE
RU	RUBBER HOSE
SD	STEEL DUCT
SS	STAINLESS STEEL
STL	STEEL
TEF	TEFLON
VC	VITRIFIED CLAY

GENERAL IDENTIFICATIONS

FC	FAIL CLOSED
FO	FAIL OPEN
H-O-A	HAND-OFF-AUTOMATIC
NC	NORMALLY CLOSED
NO	NORMALLY OPEN
ST	SAMPLE TAP
TR	TELEMETRY RECEIVER
TT	TELEMETRY TRANSMITTER
VFD	VARIABLE FREQUENCY DRIVE

EQUIPMENT DESIGNATIONS

AS	AIR STRIPPER
B	BLOWER
C	COLUMN
CP	CONTROL PANEL
D	DRUMS & POTS
DH	DUCT HEATER
E	HEAT EXCHANGER
F	FILTER
FE	FLOW ELEMENT
FH	FIRED HEATER OR BOILER
FQIT	FLOW TOTALIZING INDICATING TRANSMITTER
G	ELECTRIC POWER GENERATOR
GAC	GRANULAR ACTIVATED CARBON
GT	GAS TURBINE
K	COMPRESSOR
KR	TIMER DELAY
LAH	LEVEL ALARM HIGH
LI	LEVEL INDICATOR
LSH	LEVEL SWITCH LOW
M	MISCELLANEOUS EQUIPMENT
P	PUMP
PI	PRESSURE INDICATOR
PAL	PRESSURE ALARM LOW
PLC	PROGRAMMABLE LOGIC COMPUTER
PSL	PRESSURE SWITCH HIGH
T	TANK (ATMOSPHERIC VESSEL)
V	PRESSURE VESSEL
W	WELL

PIPING INSULATION

000	NO INSULATION
001	INSULATION
002	INSULATION WITH HEAT TRACING

LANDAU ASSOCIATES
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EDMONDS, WA. 98020
(425) 778-0907, FAX (425) 778-6409

SYM	REVISION	BY	APPROVED	DATE	SYM	REVISION	BY	APPROVED	DATE
1	PRE-FINAL DESIGN (60%)	LANDAU	KALMAR	05.02.2011					
2	90% DESIGN	LANDAU	KALMAR	05.27.2011					
3	100% DESIGN	LANDAU	KALMAR	06.23.2011					

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ACCEPTABILITY
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APPROVED BY	DEPT.	DATE

		DATE
DRAWN	B.TAYLOR	06.23.2011
CHECKED	M. VALERI	06.23.2011
ENGINEER	J.KALMAR	06.23.2011
CHECKED		
APPROVED	J.KALMAR	06.23.2011
APPROVED		

SUBTITLE: LONG-TERM STORMWATER TREATMENT SYSTEM

TITLE: PIPING AND INSTRUMENTATION LEGEND, NOTES AND DETAILS

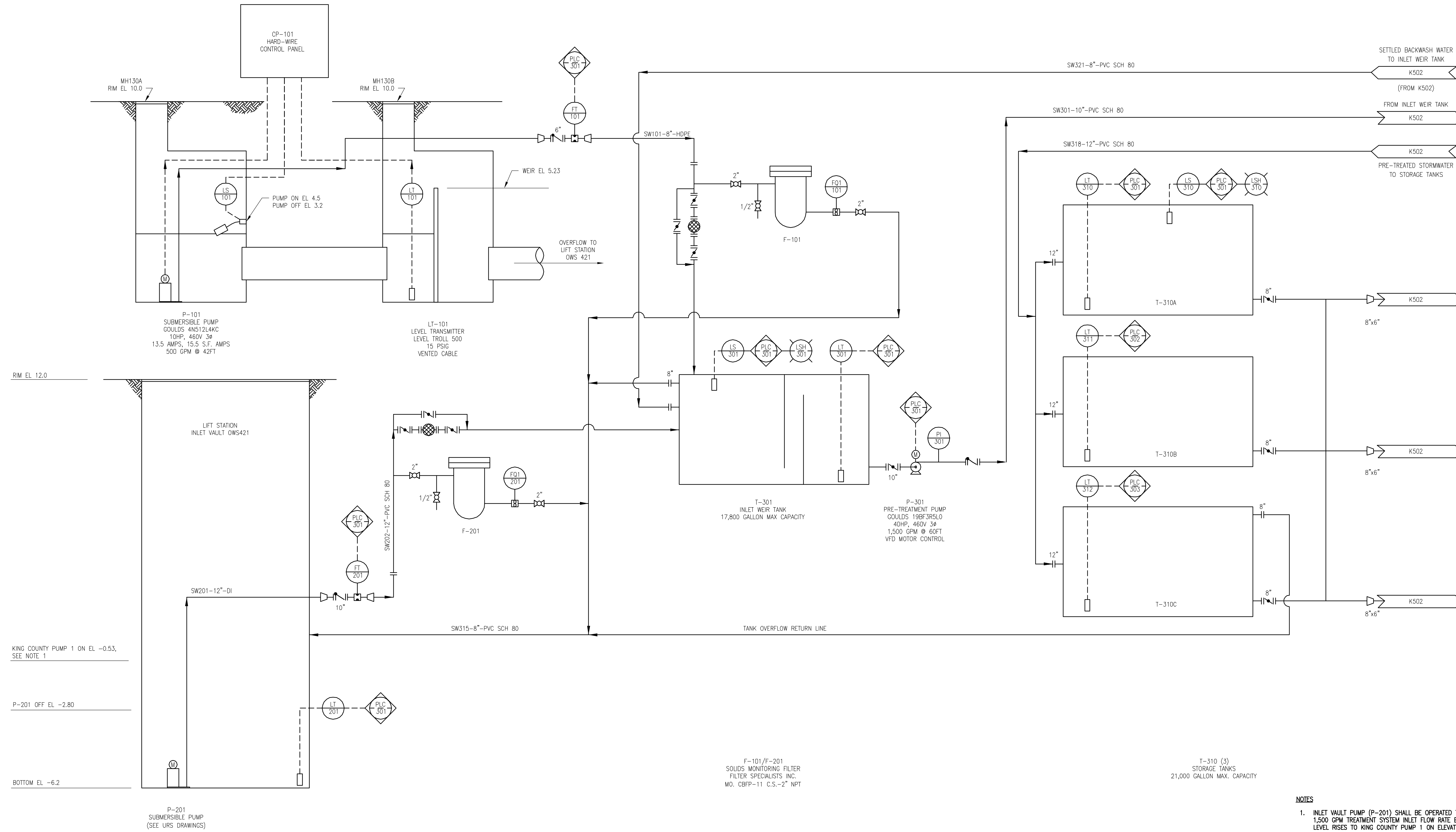
CIVIL MASTER COL. NBF

CURRENT REVISION — SYMBOL: D — DATE: 06.23.2011

SHEET: K500

JOB NO.: — COMP NO.:

DWG NO.: 3-YD-K500.DWG



NOTES

1. INLET VAULT PUMP (P-201) SHALL BE OPERATED TO ACHIEVE FULL 1,500 GPM TREATMENT SYSTEM INLET FLOW RATE BEFORE WATER LEVEL RISES TO KING COUNTY PUMP 1 ON ELEVATION OF -0.53 FT.
2. HIGH TANK LEVEL SWITCHES (LS-301, LS-310) SHALL BE MOUNTED TO ACTIVATE A HIGH LEVEL SHUTDOWN ALARM AT 1" BELOW TANK OVERFLOW PIPE ELEVATION.
3. BASKET STRAINERS SHALL BE PROVIDED WITH 1/2" PERFORATION OPENINGS.

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PIPING AND INSTRUMENTATION DIAGRAM

SCALE: N.T.S.

SYM	REVISION	BY	APPROVED	DATE	SYM	REVISION	BY	APPROVED	DATE
1	PRE-FINAL DESIGN (60%)	LANDAU	KALMAR	05.02.2011					
2	90% DESIGN	LANDAU	KALMAR	05.27.2011					
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APPROVED BY	DEPT.	DATE

		DATE
DRAWN	B.TAYLOR	06.23.2011
CHECKED	M. VALERI	06.23.2011
ENGINEER	J.KALMAR	06.23.2011
CHECKED		
APPROVED	J.KALMAR	06.23.2011
APPROVED		

SUBTITLE: LONG-TERM STORMWATER TREATMENT SYSTEM

TITLE: PIPING AND INSTRUMENTATION DIAGRAM STORMWATER COLLECTION & STORAGE

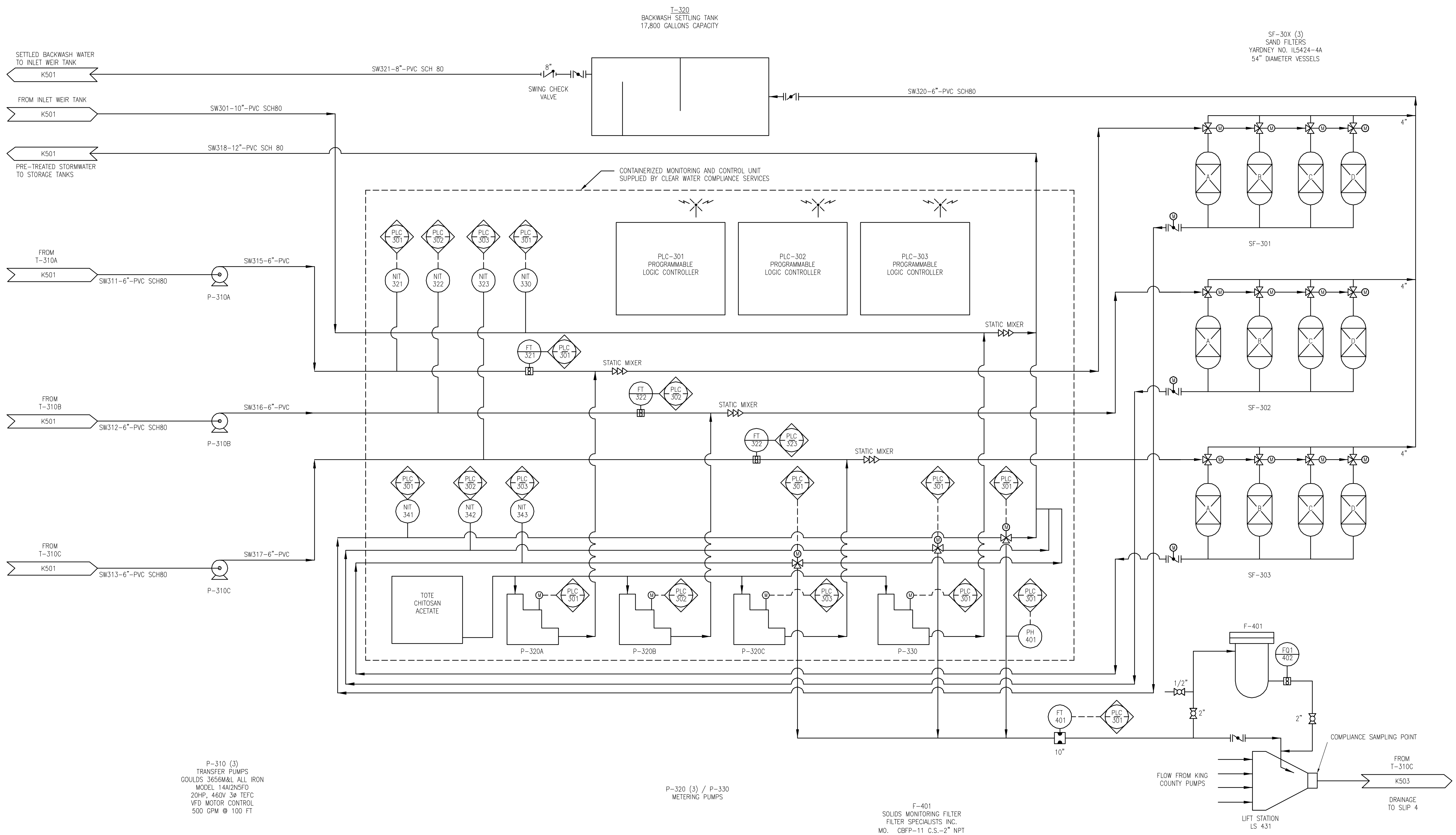
CIVIL MASTER COL. NBF

CURRENT REVISION | SYMBOL D | DATE 06.23.2011

SHEET K501

JOB NO. | COMP NO.

DWG NO. 3-YD-K501.DWG



LANDAU ASSOCIATES
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(425) 778-0907, FAX (425) 778-6409

PIPING AND INSTRUMENTATION DIAGRAM

SCALE: N.T.S.

SYM	REVISION	BY	APPROVED	DATE	SYM	REVISION	BY	APPROVED	DATE
1	PRE-FINAL DESIGN (60%)	LANDAU	KALMAR	05.02.2011					
2	90% DESIGN	LANDAU	KALMAR	05.27.2011					
3	100% DESIGN	LANDAU	KALMAR	06.23.2011					

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APPROVED BY	DEPT.	DATE

DRAWN B.TAYLOR	DATE 06.23.2011	
CHECKED M. VALERI	06.23.2011	
ENGINEER J.KALMAR	06.23.2011	
CHECKED		
APPROVED J.KALMAR	06.23.2011	
APPROVED		

SUBTITLE LONG-TERM STORMWATER TREATMENT SYSTEM

TITLE PIPING AND INSTRUMENTATION DIAGRAM STORMWATER TREATMENT AND DISCHARGE

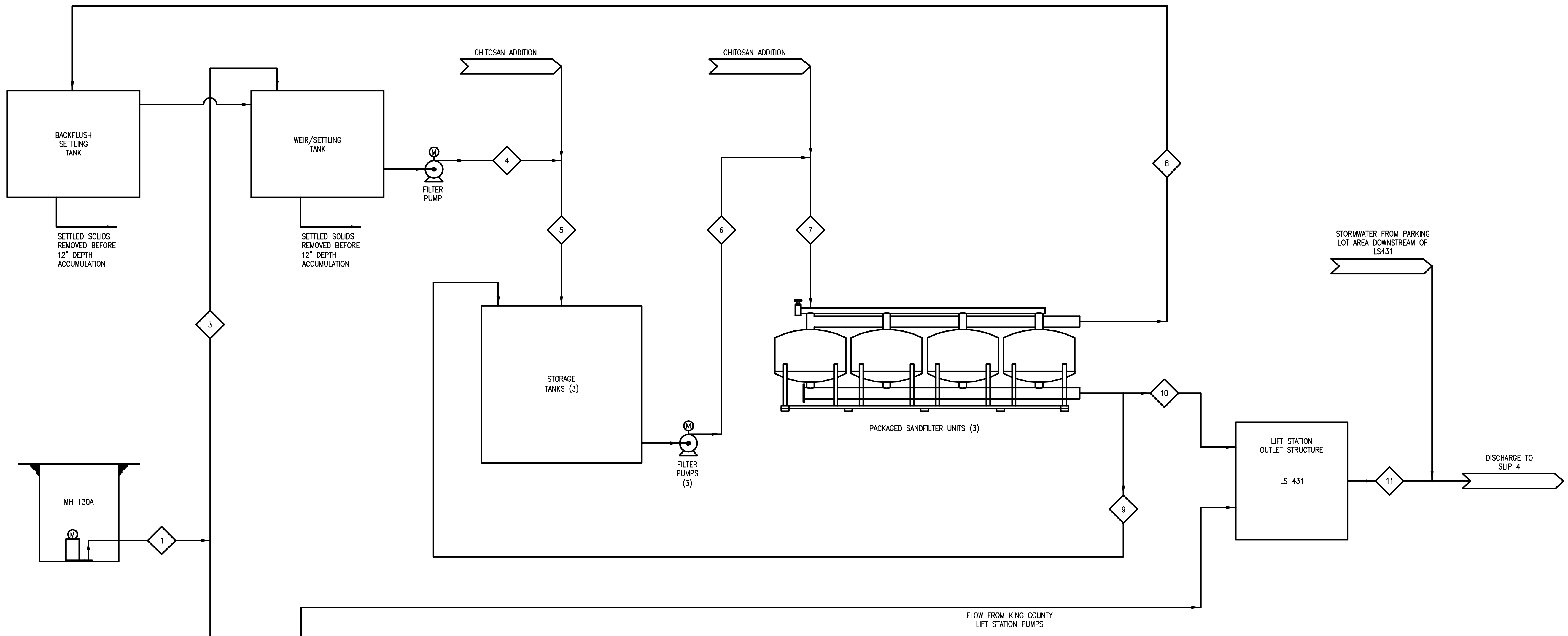
CIVIL MASTER COL. NBF

CURRENT REVISION | SYMBOL D | DATE 06.23.2011

SHEET K502

JOB NO. | COMP NO.

DWG NO. 3-YD-K502.DWG



STREAM NO.	1	2	3	4	5	6	7	8	9	10	11
DESCRIPTION	BASE FLOW/ STORMWATER FROM MH130A	BASE FLOW/ STORMWATER FROM LIFT STATION INLET VAULT	LTST SYSTEM INFLUENT	WEIR TANK EFFLUENT	STORAGE TANK INFLUENT	STORAGE TANK EFFLUENT	FILTER INFLUENT	BACKFLUSH	RECIRCULATION	LTST SYSTEM EFFLUENT	MONITORING POINT OF COMPLIANCE
DESIGN FLOW (gpm)	500	1000	1500	1650	1650	1650	1650	0/239*	0/500*	1500	VARIES
TSS (mg/L)	<20	<150	<110	<110	<110	<110	<110	VARIES	VARIES	<2.0	N/A
PCBs (µg/L)	<0.2	<0.1	<0.2	<0.2	<0.2	<0.2	<0.2	VARIES	VARIES	<0.030	<0.030
TURBIDITY (NTU)	<200	<200	<200	<200	<200	<200	<200	VARIES	≥5	<5	N/A
CHITOSAN (ppm)	0	0	0	0	0.2	≤0.2	≤0.67	VARIES	VARIES	<0.2	<0.2
PRESSURE (psi)	19	–	10	26	18	45	32	10	10	10	N/A

* MIN / MAX OF SHORT-TERM INTERMITTENT FLOWS.

PROCESS FLOW DIAGRAM

SCALE: N.T.S.

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SYM	REVISION	BY	APPROVED	DATE	SYM	REVISION	BY	APPROVED	DATE
1	PRE-FINAL DESIGN (60%)	LANDAU	KALMAR	05.02.2011					
2	90% DESIGN	LANDAU	KALMAR	05.27.2011					
3	100% DESIGN	LANDAU	KALMAR	06.23.2011					

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APPROVED BY	DEPT.	DATE

		DATE
DRAWN	B.TAYLOR	05.072.2011
CHECKED	M. VALERI	06.23.2011
ENGINEER	J.KALMAR	06.23.2011
CHECKED		
APPROVED	J.KALMAR	06.23.2011
APPROVED		

SUBTITLE: LONG-TERM STORMWATER TREATMENT SYSTEM

TITLE: STORMWATER TREATMENT PROCESS FLOW DIAGRAM

CIVIL MASTER COL. NBF

CURRENT REVISION | SYMBOL D | DATE 06.23.2011

SHEET K503

JOB NO. | COMP NO.

DWG NO. 3-YD-K503.DWG

APPENDIX B

100% Design Plans for Storm Drain Re-Route and Modifications

3-YD PHASE 2 RE-ROUTE STORMWATER LINES

THE BOEING COMPANY
SEATTLE, WASHINGTON

Boeing Project No. E-XXXXXXXX / C-XXXXXXXX

100% DESIGN

June 24, 2011

SOURCE: GOOGLE EARTH PRO

VICINITY PLAN
SCALE: NTS

SOURCE: GOOGLE EARTH PRO

PROJECT LOCATION PLAN
SCALE: NTS

DRAWING INDEX

APPLICABLE CODES & STANDARDS

- CITY OF SEATTLE STANDARD PLANS FOR MUNICIPAL CONSTRUCTION, 2011 EDITION
- CITY OF SEATTLE STANDARD SPECIFICATIONS FOR ROAD, BRIDGE AND MUNICIPAL CONSTRUCTION, 2011 EDITION
- CITY OF SEATTLE STORMWATER MANUAL, 2009 EDITION
- BOEING DRAWING AND DESIGN STANDARDS
- THE 2009 INTERNATIONAL BUILDING CODE WITH 2007 WA AMENDMENTS (WASHINGTON ADMINISTRATIVE CODE (WAC) 51-50)
- NATIONAL ELECTRICAL CODE NFPA 70-2008, WA AMENDMENTS (WAC 296-46B)
- NATIONAL ELECTRICAL SAFETY CODE NESC C2-2007
- INTERNATIONAL FIRE CODE AS ADOPTED BY WAC 51-54
- OCCUPATIONAL SAFETY AND HEALTH STANDARDS, CFR 29, CHAPTER XVII, PART 1910
- WASHINGTON INDUSTRIAL SAFETY AND HEALTH ACT (WISHA), TITLE 296 WAC
- 2005 STORMWATER MANAGEMENT MANUAL FOR WESTERN WASHINGTON
- UNDERWRITERS LABORATORIES (UL)
- INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)
- NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)
- AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)
- AMERICAN WATER WORKS ASSOCIATION (AWWA)
- AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)
- WASHINGTON STATE DEPARTMENT OF TRANSPORTATION (WSDOT) STANDARD SPECIFICATIONS FOR ROAD, BRIDGE, AND MUNICIPAL CONSTRUCTION, 2010 EDITION

PROJECT DIRECTORY

Boeing Shared Services Group — Owner
P.O. Box 3707
Seattle, Washington 98124

URS Corporation — Civil Engineering, Geotechnical Engineering, Mechanical Engineering, Electrical Engineering, Structural Engineering
Century Square
1501 4th Avenue, Suite 1400
Seattle, Washington 98101-1616
206-438-2700

URS
1501 4TH AVENUE, STE. 1400
SEATTLE, WA 98101-1616
TELEPHONE (206) 438-2700

SYM	REVISION	BY	APPROVED	DATE	SYM	REVISION	BY	APPROVED	DATE
A	PHASE 2 RE-ROUTE STORMWATER LINES - 60% DESIGN	URS	CASTRO	04.29.11					
B	PHASE 2 RE-ROUTE STORMWATER LINES - 90% DESIGN	URS	CASTRO	05.27.11					
C	PHASE 2 RE-ROUTE STORMWATER LINES - 100% DESIGN	URS	CASTRO	06.24.11					

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APPROVED BY	DEPT.	DATE

		DATE
DRAWN	STICKEL	06.24.11
CHECKED		
ENGINEER	CASTRO	06.24.11
CHECKED		
APPROVED		
APPROVED		

SUBTITLE: COVER SHEET

TITLE: PHASE 2 RE-ROUTE STORMWATER LINES
NORTH BOEING FIELD

COL. NBF

CURRENT REVISION	SYMBOL D	DATE 06.24.11
SHEET G0		
JOB NO.		COMP NO.
DWG NO. 3.YD-G0		

Mod: 06/22/2011, 15:52 | Plotted: 06/24/2011, 10:53 | larry_jiles

Q:\Boeing\NBF\PEL Remediation\Phase 2 Re-Route Storm Lines\R03\Civil\3-YD-G0 - Cover Sheet.dwg

ABBREVIATIONS

#	NUMBER
@	AT
'	FEET
"	INCH
AASHTO	AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS
ACI	AMERICAN CONCRETE INSTITUTE
AISC	AMERICAN INSTITUTE OF STEEL CONSTRUCTION
ANSI	AMERICAN NATIONAL STANDARDS INSTITUTE
APPROX	APPROXIMATE, APPROXIMATELY
ASCE	AMERICAN SOCIETY OF CIVIL ENGINEERS
ASTM	AMERICAN SOCIETY FOR TESTING AND MATERIALS
AWS	AMERICAN WELDING SOCIETY
AWWA	AMERICAN WATER WORKS ASSOCIATION
BF	BOTTOM FACE
BGS	BELOW GROUND SURFACE
BIGD	BELOW INLET GRATE DEVICE
BMP	BEST MANAGEMENT PRACTICES
BOT	BOTTOM
C	CONCRETE
C/L	CENTERLINE
CB	CATCH BASIN
C-C	CENTER TO CENTER
CDF	CONTROLLED DENSITY FILL
CFR	CODE OF FEDERAL REGULATIONS
CL	CENTERLINE
CLR	CLEAR
CO.	COUNTY
DEPT	DEPARTMENT
DI	DUCTILE IRON
DIP	DUCTILE IRON PIPE
DTL	DETAIL
DWG	DRAWING
E	EAST
E.G.	EXAMPLE
EA	EACH
EL	ELEVATION
ESC	EROSION AND SEDIMENT CONTROL
ETC	ET CETERA
FL	FLOW LINE, FLANGE
FLR	FLOOR
FT	FEET
G	GENERAL
GND	GROUND
GRC	GALVANIZED RIGID CONDUIT
H	HEIGHT
HDPE	HIGH DENSITY POLYETHYLENE
HP	HORSEPOWER
HYD	HYDRANT
IBC	INTERNATIONAL BUILDING CODE
ICC	INTERNATIONAL CODE COUNCIL
ID	INSIDE DIAMETER, INSIDE DIMENSIONS
IE	INVERT ELEVATION
IEEE	INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS
IN	INCH
INV	INVERT
KAIC	THOUSAND AMPERES INTERRUPTING CURRENT
KC	KING COUNTY
KCMIL	THOUSAND CIRCULER MILS
KV	KILOVOLT
LB	POUND
LTST	LONG-TERM STORMWATER TREATMENT
MAX	MAXIMUM
MH	MANHOLE
MIN	MINIMUM
MJ	MECHANICAL JOINT
MPH	MILES PER HOUR
N	NORTH
NBF	NORTH BOEING FIELD
NE	NORTHEAST
NEC	NATIONAL ELECTRIC CODE
NEMA	NATIONAL ELECTRICAL MANUFACTURER'S ASSOCIATION
NGVD	NATIONAL GEODETIC VERTICAL DATUM
NO.	NUMBER
NTS, N.T.S	NOT TO SCALE
NW	NORTHWEST
O/W	OIL/WATER
OC	ON CENTER
OCT.	OCTOBER
OD	OUTSIDE DIAMETER
OSHA	OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION
OWS	OIL/WATER SEPARATOR
ϕ, DIA	DIAMETER
P	PIPE
PAV	PAVEMENT
PNL	PANEL
PSF	POUNDS PER SQUARE FOOT
PVC	POLYVINYL CHLORIDE
PWR	POWER
R.C.P.E.S	REINFORCED CONCRETE PIPE EXISTING SYSTEM
RCP	REINFORCED CONCRETE PIPE
REQ'D	REQUIRED
REV	REVISION/REVISED
RGS	RIGID GALVANIZED STEEL
RSC	RIGID STEEL CONDUIT
S	SOUTH, SLOPE
S.S	STAINLESS STEEL
SAN	SANITARY SEWER
SCL	SEATTLE CITY LIGHT
SDMH	STORM DRAIN MANHOLE
SDR	STANDARD DIMENSION RATIO
SE	SOUTHEAST
SQ	SQUARE
SSMH	STORM SEWER MANHOLE
SSTL	STAINLESS STEEL
STA	STATION
STE	SUITE
STS	STORM SEWER
SUB	SUBSTATION
SW	SOUTHWEST
SYM	SYMBOL
TESC	TEMPORARY EROSION AND SEDIMENT CONTROL
TF	TOP FACE
THHN	HEAT RESISTANT THERMOPLASTIC
THW	MOISTURE AND HEAT-RESISTANT THERMOPLASTIC
TYP	TYPICAL
UG	UNDERGROUND
UL	UNDERWRITERS LABORATORIES
U.N.O.	UNLESS NOTED OTHERWISE
V	VOLT
VAR	VARIABLE
VFD	VARIABLE FREQUENCY DRIVE
W	WEST
W/	WITH
WA	WASHINGTON
WAC	WASHINGTON ADMINISTRATIVE CODE
WISHA	WASHINGTON INDUSTRIAL SAFETY AND HEALTH ACT
WSDOT	WASHINGTON STATE DEPARTMENT OF TRANSPORTATION
XFMR	TRANSFORMER
XHHW	MOISTURE HEAT RESISTANT THERMOSET
YD	YARD

ABBREVIATIONS:
THROUGHOUT THE PLANS ARE ABBREVIATIONS WHICH ARE IN COMMON USE. THE LIST OF ABBREVIATIONS PROVIDED IS NOT INTENDED TO BE COMPLETE OR REPRESENTATIVE OF CONDITIONS OR MATERIALS ACTUALLY USED ON THE PROJECT. THE TECHNICAL REPRESENTATIVE WILL DEFINE THE INTENT OF ANY ABBREVIATION IN QUESTION.

LEGEND

EXISTING

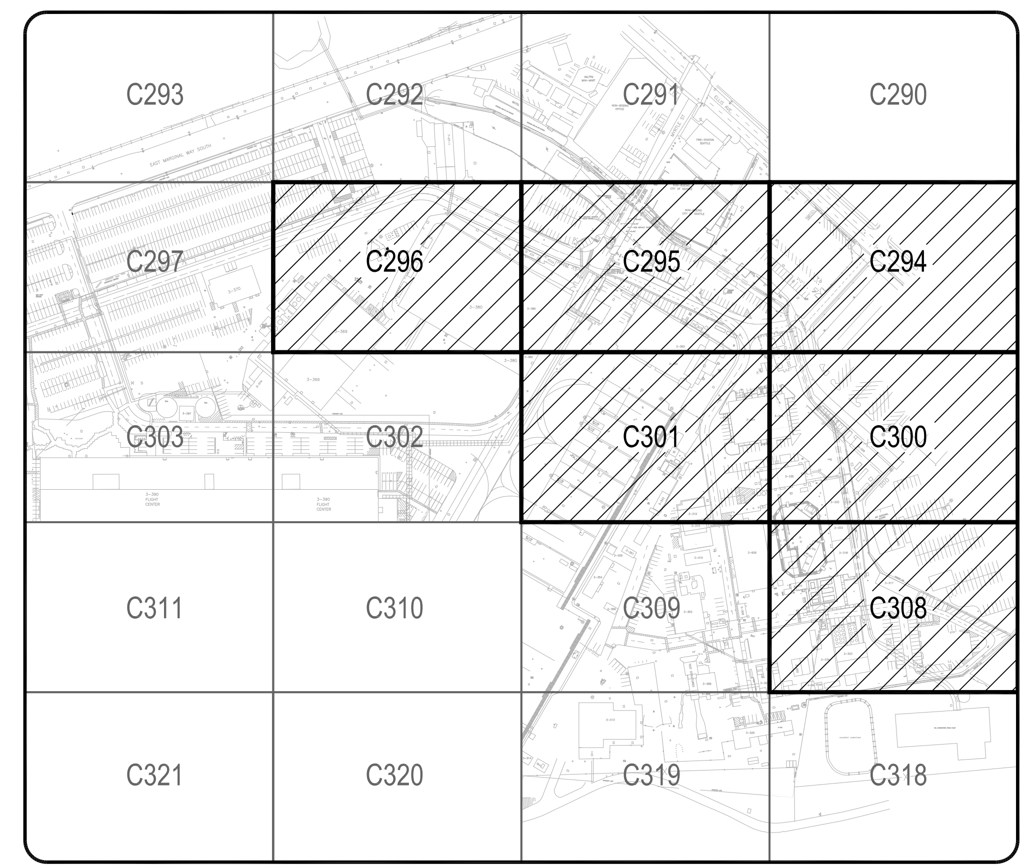
- MATCHLINE
- EXISTING EDGE OF PAVEMENT
- x — x — x — EXISTING FENCE
- STS — STS — STS — EXISTING STORM SEWER
- SAN — SAN — SAN — EXISTING SANITARY SEWER
- F — EXISTING FIRE SUPPLY
- PW — EXISTING PROCESS WATER
- CW — EXISTING COLD WATER
- A — A — A — A — EXISTING AIR SUPPLY
- G — EXISTING GAS
- P — EXISTING POWER
- EXISTING UTILITY STRIPING
- FO — FO — FO — EXISTING FUEL OIL
- EXISTING LIGHTS
- EXISTING CATCH BASIN
- EXISTING MANHOLE
- EXISTING WATER VALVE
- EXISTING FIRE HYDRANT
- EXISTING BOLLARD

PROPOSED

- STS — STS — STS — STORM SEWER
- FORCEMAIN
- FORCEMAIN (SPARE LINE)
- E — E — E — E — ELECTRICAL CONDUIT
- ABANDON AND FILL AND PLUG STORMWATER PIPE
- TEMPORARY INLET PROTECTION, SEE 2/C500
- MANHOLE
- ELECTRICAL PULL BOX

GENERAL NOTES

1. VERIFY ALL EXISTING UTILITIES BEFORE COMMENCING WORK. NOTIFY THE ENGINEER IN WRITING OF EXISTING CONDITIONS THAT DIFFER FROM THOSE SHOWN ON THE DRAWINGS. LOCATIONS OF EXISTING UTILITIES AS SHOWN ON THE CONSTRUCTION DRAWINGS ARE BASED ON DRAWINGS PROVIDED BY THE OWNER. LOCATIONS ARE NOT GUARANTEED TO BE COMPLETE OR ACCURATE. CONTRACTOR SHALL POTHOLE UNDERGROUND UTILITY CROSSING OR CONNECTION LOCATIONS, PRIOR TO CONSTRUCTION AS NECESSARY TO AVOID CONFLICTS AND/OR VERIFY LINE SIZE, MATERIAL TYPE AND INVERT ELEVATION. CONTRACTOR SHALL NOTIFY OWNER IMMEDIATELY OF ANY CONFLICTS NOT SHOWN ON THE PLANS AND SHALL KEEP EXISTING UTILITIES IN SERVICE AND PROTECT THEM DURING CONSTRUCTION. WHERE INTERRUPTION OF EXISTING FACILITIES IS REQUIRED, CONTRACTOR SHALL PROVIDE 72 HOURS NOTICE TO THE OWNER AND THE AFFECTED UTILITY. CONTRACTOR SHALL ARRANGE FOR THE TEMPORARY RELOCATION OF ANY UTILITIES IN CONFLICT WITH THE PROPOSED CONSTRUCTION.
2. ENGINEER DOES NOT WARRANT THAT UTILITIES ARE SHOWN, THAT UTILITIES SHOWN EXIST OR THAT UTILITIES SHOWN ARE IN THE LOCATIONS INDICATED. CONTRACTOR SHALL USE EXTREME CAUTION WHEN EXCAVATING PIPELINES, STRUCTURES AND APPURTENANCES SO AS NOT TO DISTURB EXISTING UTILITIES AND PIPELINES OR UNNECESSARILY DAMAGE SURROUNDING VEGETATION. CONTRACTOR SHALL REROUTE, REPLACE OR, EXTEND OR OTHERWISE ALTER EXISTING UNDERGROUND UTILITIES AND CONDUITS WHICH ARE DISTURBED AS PART OF THIS WORK TO THE ULTIMATE SATISFACTION OF THE OWNER AT NO ADDITIONAL COST TO THE OWNER. CONTRACTOR SHALL NOTIFY UNDERGROUND SERVICE ALERT AT LEAST 48 HOURS IN ADVANCE OF ANY DIGGING. UTILITIES UNDERGROUND LOCATION CENTER 1-800-424-5555.
3. DRAWINGS SHALL NOT BE SCALED. GRAPHIC SCALES ARE INCLUDED ON THE DRAWINGS FOR CONVENIENCE ONLY. WHERE DIMENSIONS SHOWN IN THE DRAWINGS CONFLICT, LARGER SCALE DRAWINGS SHALL HAVE PRECEDENCE.
4. CONTRACTOR IS RESPONSIBLE FOR THE VERIFICATION AND COORDINATION OF THE WORK OF ALL TRADES, TO ASSURE COMPLIANCE WITH THE CONTRACT DOCUMENTS.
5. THE LOCATIONS OF EXISTING UTILITIES AND FEATURES ARE APPROXIMATE. CONTRACTOR SHALL VERIFY ACTUAL LOCATIONS PRIOR TO CONSTRUCTION. CONTRACTOR SHALL BE CAUTIOUS WHEN EXCAVATING NEAR EXISTING UTILITIES. CONTRACTOR SHALL BE RESPONSIBLE FOR DAMAGES CAUSED TO EXISTING UTILITIES.
6. IF NECESSARY, SAW-CUT TO CURBS AND SIDEWALKS SHALL BE DONE AT DUMMY JOINT OR FULL EXPANSION JOINT.
7. ON COMPLETION OF UTILITIES INSTALLATION IN ROADWAY OR PARKING AREAS, CONTRACTOR SHALL PAINT NEW STRIPING MARK OVER WORK AREA. CONTRACTOR SHALL PRESSURE WASH EXISTING STRIPE MARKINGS THAT WERE AFFECTED BY CONSTRUCTION, AND PAINT NEW STRIPE MARKING AS REQUIRED. NEW STRIPING MARK SHALL COVER THE FULL LENGTH OF EACH STRIPE. LOCATION AND SIZE OF NEW PAINT STRIPE ON ROADWAY AND PARKING AREA SHALL BE IDENTICAL TO MARKING PRIOR TO CONSTRUCTION.
8. UNLESS OTHERWISE NOTED, CONTRACTOR SHALL REFER TO CITY OF SEATTLE STANDARD PLANS AND SPECIFICATIONS FOR MUNICIPAL CONSTRUCTION, 2011 EDITION.
9. ALL WORK SHALL BE PERFORMED IN A WORKMANLIKE MANNER AND IN CONFORMANCE WITH APPLICABLE CODES, REGULATIONS AND PERMIT REQUIREMENTS.
10. RECORD DRAWINGS: CONTRACTOR SHALL BE RESPONSIBLE FOR MAINTAINING A CLEAN SET OF DRAWINGS AT THE PROJECT OFFICE FOR RECORD INFORMATION. ALL REQUIRED INFORMATION SHALL BE RECORDED IN RED PENCIL DAILY IN A NEAT AND LEGIBLE MANNER.
11. CONTRACTOR SHALL OBTAIN ALL PERMITS REQUIRED FOR CONSTRUCTION.
12. ALL DISTURBED PROPERTY AND VEGETATION SHALL BE RESTORED TO ORIGINAL CONDITION OR BETTER AS SPECIFIED.
13. CONTRACTOR SHALL PROTECT ALL SURVEY MONUMENTS AND BENCHMARKS. CONFIRM INDICATED VERTICAL AND HORIZONTAL CONTROL AND MONUMENTS PRIOR TO CONSTRUCTION. REPORT ANY DISCREPANCIES.
14. THE CONTRACTOR SHALL MAINTAIN ALL SIGNS, BARRICADES, WARNING LIGHTS AND OTHER DEVICES NECESSARY FOR SAFETY.
15. THE SPECIFICATION OF A NAME BRAND PRODUCT, OR EQUIVALENT, IS MADE TO ESTABLISH THE LEVEL OF QUALITY OF THE MATERIALS AND EQUIPMENT REQUIRED AND IS NOT A PRODUCT ENDORSEMENT. SUBMIT SUBSTITUTIONS IN WRITING IN ACCORDANCE WITH SPECIFICATIONS FOR APPROVAL.
16. GRADING/FILLING ON-SITE SHALL NOT ADVERSELY AFFECT ADJOINING SITES.
17. CLEARING IS NOT ANTICIPATED TO BE NECESSARY FOR THIS PROJECT. IF CLEARING DOES BECOME NECESSARY, CLEARING LIMITS SHALL BE STAKED, FLAGGED, AND/OR FENCED OFF PRIOR TO INITIATION OF ANY CLEARING OR LAND ALTERATION ACTIVITIES.
18. DURING CONSTRUCTION, SUPPORT AND PROTECT FROM DAMAGE AS NECESSARY ALL EXISTING UTILITIES IN THE VICINITY OF THE WORK. CONTRACTOR SHALL BE RESPONSIBLE FOR ALL DAMAGE TO SUCH EXISITING UTILITIES.
19. NOTIFY OWNERS OF EXISTING UTILITIES WHICH ARE WITHIN 15 FEET OF PROPOSED TRENCH EXCAVATIONS, PRIOR TO PROCEEDING WITH SUCH EXCAVATIONS.
20. WHEN CONTRACTOR DETERMINES THAT AN EXISTING UTILITY MUST BE RELOCATED, NOTIFY BOEING AND UTILITY OWNER IN SUFFICIENT TIME PRIOR TO APPROACHING THE UTILITY TO AVOID DELAY OF THE WORK.
21. CONTRACTOR WILL PERFORM WORK IN A MANNER WHICH MINIMIZES DISTURBANCE TO OWNER'S ONGOING ACTIVITIES AT THE SITE. CONTRACTOR SHALL ENFORCE STRICT DISCIPLINE AND GOOD ORDER AMONG ITS EMPLOYEES AT ALL TIMES. CONTRACTOR SHALL NOT EMPLOY ANY PERSON UNFIT OR UNSKILLED IN ANY PROJECT ASSIGNED TO HIM.
22. THE CONTRACTOR SHALL NOT OPEN MORE TRENCHES THAN CAN BE PROPERLY BACKFILLED IN A DAY'S OPERATION. ANY TRENCH UNAVOIDABLY LEFT OPEN DURING THE HOURS OF DARKNESS OR OVER A WEEKEND SHALL BE BRIDGED BY A STEEL TRAFFIC PLATE.
23. ALL REMOVALS IN PAVED AREAS SHALL BE SAWCUT ON A NEAT, STRAIGHT LINE PARALLEL TO THE WORK OR PIPE LINE. THE CUT EDGE SHALL BE PROTECTED FROM CRUSHING AND ALL BROKEN EDGES SHALL BE RECUT PRIOR TO PAVING OPERATIONS.
24. DUST SHALL BE CONTROLLED BY APPROVED METHODS.
25. PUBLIC STREETS AND ACTIVE OPERATIONS AREA SHALL BE KEPT CLEAN AND FREE FROM DIRT AND/OR DEBRIS. THE CONTRACTOR SHALL BE RESPONSIBLE FOR ALL COSTS INCURRED IN STREET CLEANING NECESSITATED BY HIS OPERATION.
26. THE CONTRACTOR SHALL BE RESPONSIBLE FOR PAVEMENT REPLACEMENT FOR ALL TRENCH CUTS AND DAMAGE TO EXISTING PAVEMENT.
27. IF RESOURCES OF POTENTIAL ARCHAEOLOGICAL SIGNIFICANCE ARE ENCOUNTERED DURING CONSTRUCTION OR EXCAVATION, THE CONTRACTOR SHALL IMMEDIATELY STOP WORK AND NOTIFY THE ENGINEER AND OWNER. THE OWNER WILL NOTIFY THE PROPER AUTHORITIES FOR AN EVALUATION BEFORE CONSTRUCTION RESUMES IN THAT AREA.
28. RIM ELEVATIONS PROVIDED ON THESE DRAWINGS FOR NEW STRUCTURES ARE APPROXIMATE. THE CONTRACTOR SHALL FIELD SET THE NEW STRUCTURES SO THAT THEY MATCH EXISTING GRADE.
29. NEW MANHOLES MH-CG1, MH-BG, MH-CG SHOWN ON DRAWINGS C296 AND C308 WERE INCORPORATED INTO THE DESIGN TO AVOID POTENTIAL CONFLICTS WITH EXISTING STORM SEWER LINES. IF IT IS DISCOVERED THAT THERE IS NO CONFLICT WITH THE NEW 24-INCH STORM SEWER LINE AND EXISTING STORM SEWER LINES, THE ENGINEER HAS THE OPTION TO DIRECT THE CONTRACTOR NOT TO INSTALL A 54-INCH MANHOLE.
30. SURVEY DATUM FOR THESE DRAWINGS IS NAD83-91 (HORIZONTAL) AND NGVD 29 (VERTICAL).
31. THE MINIMUM DESIGN SLOPE OF THE NEW 24-INCH STORM SEWER LINE IS 0.1%.
32. EXISTING CATCH BASINS AND STORM SEWER PIPES, AFFECTED BY THE WORK, MAY HAVE TO BE REMOVED AND REPLACED TO ACCOMMODATE THE PIPE(S) INSTALLATION.



KEY PLAN
SCALE: NTS

Mod: 06/24/2011, 08:06 | Plotted: 06/24/2011, 10:41 | larry_illes

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URS
1501 4TH AVENUE, STE. 1400
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TELEPHONE (206) 438-2700

SYM	REVISION	BY	APPROVED	DATE
A	PHASE 2 RE-ROUTE STORMWATER LINES – 60% DESIGN	URS	CASTRO	04.29.11
B	PHASE 2 RE-ROUTE STORMWATER LINES – 90% DESIGN	URS	CASTRO	05.27.11
C	PHASE 2 RE-ROUTE STORMWATER LINES – 100% DESIGN	URS	CASTRO	06.24.11

BOEING®

ACCEPTABILITY
THIS DESIGN AND/OR SPECIFICATION IS APPROVED

APPROVED BY	DEPT.	DATE

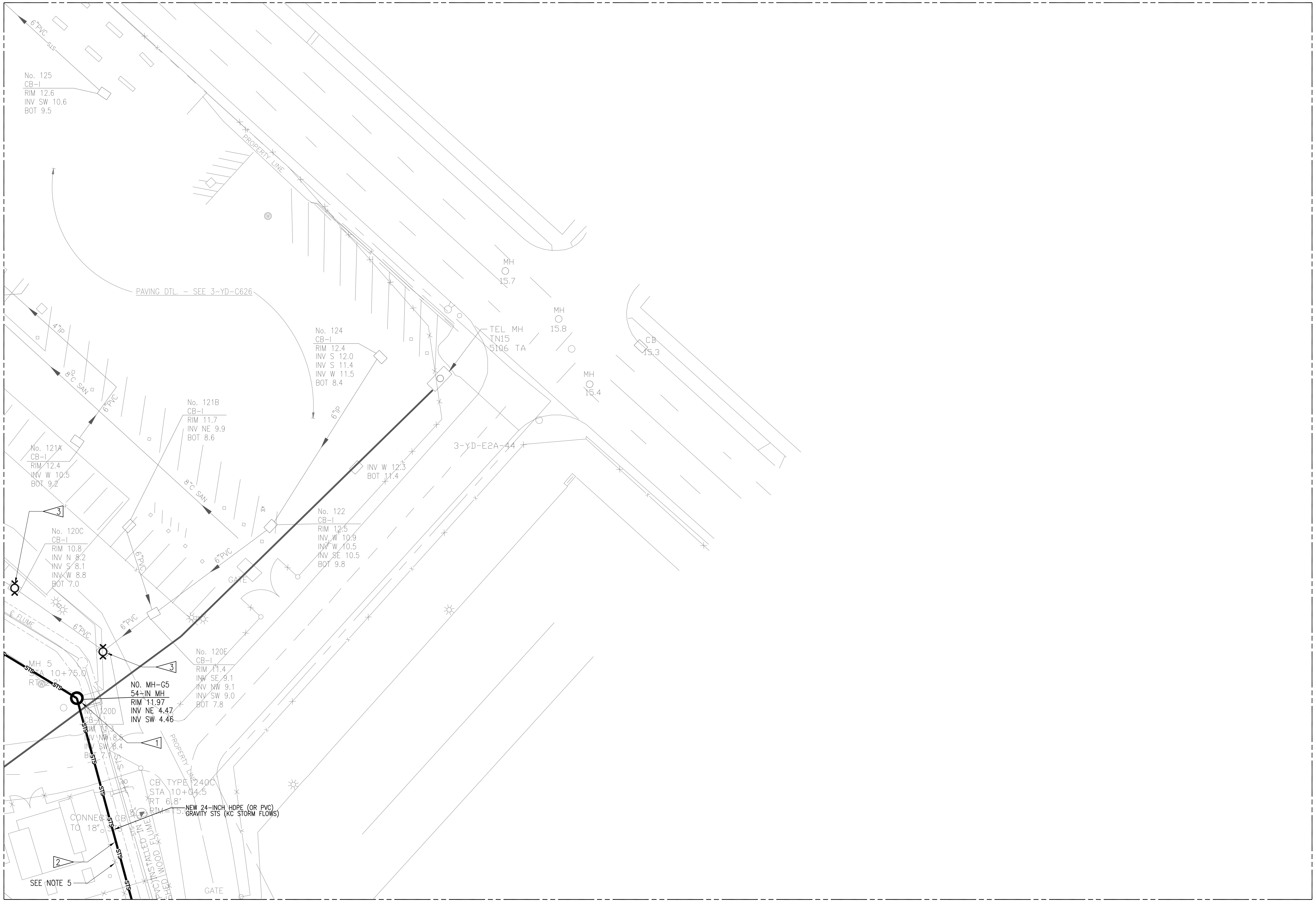
DRAWN	STICKEL	06.24.11
CHECKED		
ENGINEER	CASTRO	06.24.11
CHECKED		
APPROVED		
APPROVED		

SUBTITLE: KEY SHEET

TITLE: PHASE 2 RE-ROUTE STORMWATER LINES
NORTH BOEING FIELD

COL. NBF

CURRENT REVISION	
SYMBOL	D
DATE	06.24.11
SHEET	C1
JOB NO.	
COMP NO.	
DWG NO.	3.YD-C1



MATCHLINE - FOR CONTINUATION SEE SHEET C300

LEGEND:

- STS — STORM SEWER
- FORCEMAIN
- TEMPORARY INLET PROTECTION, SEE 2/C500
- MANHOLE

GENERAL NOTES:

1. THE STORMWATER LINE SHOWN SHALL BE 24-INCH HDPE, SDR 17 OR PVC PIPE (PS46).
2. THE OUTSIDE WALL OF THE 24-INCH STORMWATER LINE SHALL BE A MINIMUM OF 12 INCHES FROM THE OUTSIDE WALL OF THE EXISTING 18" STS LINE.
3. TO THE EXTENT POSSIBLE, THE ALIGNMENT OF THE 24-INCH STORMWATER LINE FOLLOWS THE ALIGNMENT OF THE DEMOLISHED WOOD FLUME. THE WOOD FLUME WAS DEMOLISHED IN A PREVIOUS PROJECT. IT MAY BE NECESSARY TO REMOVE THE WALLS AND BOTTOM OF THE WOOD FLUME, IF PORTIONS STILL REMAIN, IN ORDER TO INSTALL THE 24-INCH STORMWATER LINE.
4. THE RIM ELEVATION OF THE NEW MANHOLE STRUCTURES SHALL BE SUCH THAT THE RIMS MATCH SURROUNDING GRADE.
5. EXISTING FENCE MAY REQUIRE REMOVAL AND REPLACEMENT TO ACCOMMODATE PIPE INSTALLATION.

CONSTRUCTION NOTES:

1. INSTALL 54-INCH MANHOLE, SEE 1/C501.
2. INSTALL 24-INCH HDPE (OR PVC) PIPE, SEE 5/C502.
3. INSTALL TEMPORARY INLET PROTECTION, SEE 2/C500.

20' 10' 0 20' 40'
SCALE IN FEET

											C293	C292	C291	C290
								C299	C298	C297	C296	C295	C294	
					C307	C306	C305	C304	C303	C302	C301	C300		
C333	C332		C317	C316	C315	C314	C313	C312	C311	C310	C309	C308		
C331	C330	C329	C328	C327	C326	C325	C324	C323	C322	C321	C320	C319	C318	

KEY PLAN
SCALE: NONE

Mod: 06/24/2011, 11:28 | Plotted: 06/24/2011, 11:34 | larry_jiles
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SYM	REVISION	BY	APPROVED	DATE
A	PHASE 2 RE-ROUTE STORMWATER LINES - 60% DESIGN	URS	CASTRO	04.29.11
B	PHASE 2 RE-ROUTE STORMWATER LINES - 90% DESIGN	URS	CASTRO	05.27.11
C	PHASE 2 RE-ROUTE STORMWATER LINES - 100% DESIGN	URS	CASTRO	06.24.11

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ACCEPTABILITY
THIS DESIGN AND/OR SPECIFICATION IS APPROVED

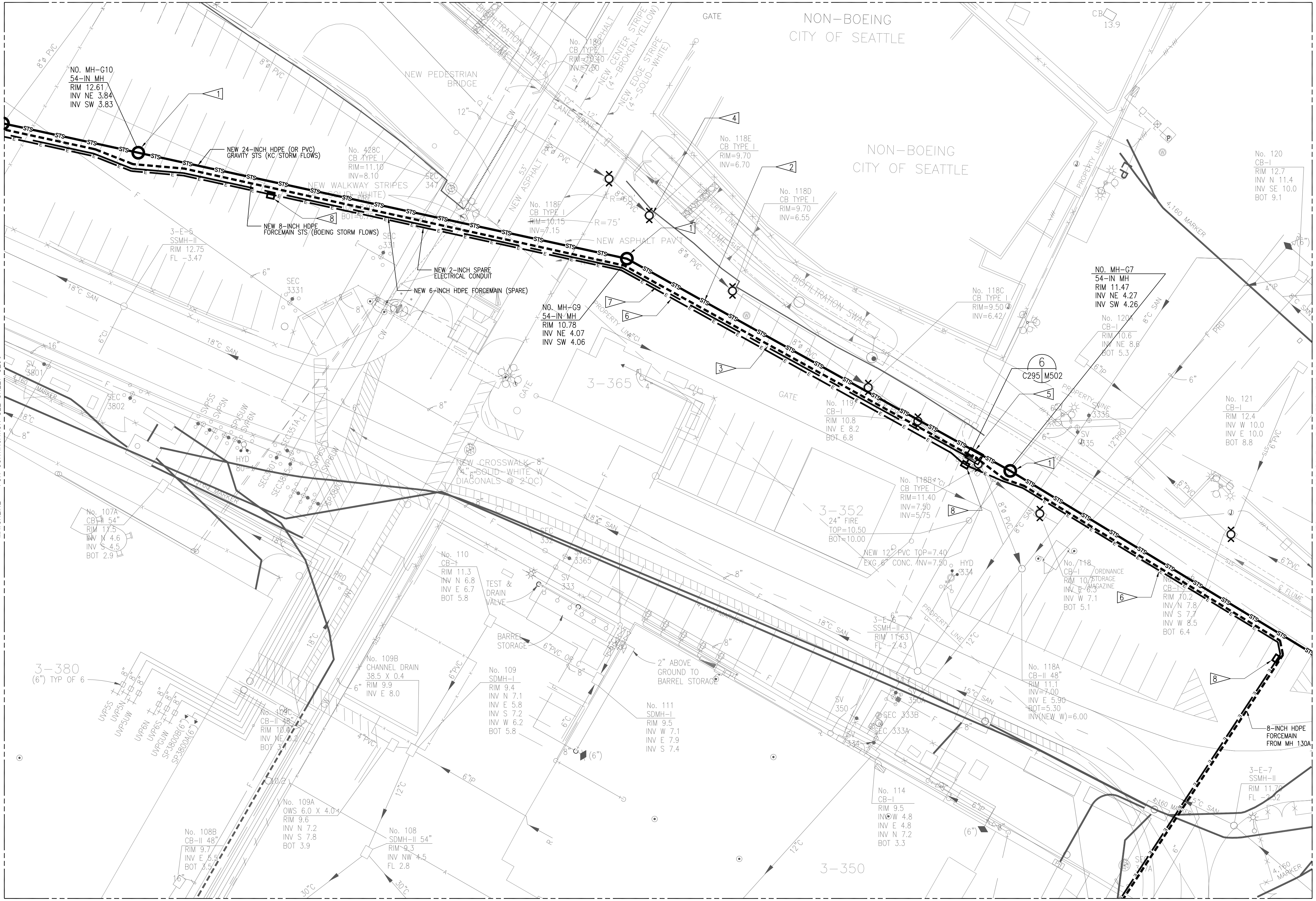
APPROVED BY	DEPT.	DATE

DRAWN	STICKEL	06.24.11
CHECKED		
ENGINEER	CASTRO	06.24.11
CHECKED		
APPROVED		
APPROVED		

SUBTITLE: STORM AND SANITARY SEWER
TITLE: PHASE 2 RE-ROUTE STORMWATER LINES
NORTH BOEING FIELD

CIVIL MASTER COL. NBF

CURRENT REVISION — SYMBOL: D — DATE: 06.24.11
SHEET: C294
JOB NO.
COMP NO.
DWG NO.: 3.YD-C294



MATCHLINE – FOR CONTINUATION SEE SHEET C301

LEGEND:

- STS — STORM SEWER
- FORCEMAIN
- FORCEMAIN (SPARE LINE)
- E — ELECTRICAL CONDUIT
- TEMPORARY INLET PROTECTION, SEE 2/C500
- MANHOLE
- ELECTRICAL PULLBOX

GENERAL NOTES:

1. THE STORMWATER LINE SHOWN SHALL BE 24-INCH HDPE, SDR 17 OR PVC PIPE (PS46).
2. THE STORMWATER FORCEMAIN SHOWN SHALL BE 8-INCH HDPE, SDR 17.
3. THE OUTSIDE WALL OF THE 24-INCH STORMWATER LINE SHALL BE A MINIMUM OF 12 INCHES FROM THE OUTSIDE WALL OF THE EXISTING 18" STS LINE.
4. THE OUTSIDE WALL OF THE 8-INCH STORMWATER FORCEMAIN SHALL BE A MINIMUM OF 12 INCHES FROM THE OUTSIDE WALL OF THE 24-INCH STORMWATER LINE.
5. TO THE EXTENT POSSIBLE, THE ALIGNMENT OF THE 24-INCH STORMWATER LINE FOLLOWS THE ALIGNMENT OF THE DEMOLISHED WOOD AND/OR CONCRETE FLUME. THE CONCRETE FLUME WAS DEMOLISHED TO 2 FEET BELOW GROUND SURFACE (BGS) IN A PREVIOUS PROJECT. THE WOOD FLUME WAS COMPLETELY DEMOLISHED. IT MAY BE NECESSARY TO REMOVE THE WALLS AND BOTTOM OF THE FLUME BELOW 2 FEET BGS IN ORDER TO INSTALL THE 24-INCH STORMWATER LINE AND 8-INCH STORMWATER FORCEMAIN.
6. THE RIM ELEVATION OF THE NEW MANHOLE AND VAULT STRUCTURES SHALL BE SUCH THAT THE RIMS MATCH SURROUNDING GRADE.
7. AT THE ENGINEER'S DIRECTION, PROVIDE AIR RELEASE VALVE ON 8-INCH HDPE FORCEMAIN AT ALL HIGH POINTS ON THE FORCEMAIN. SEE SHEET M503 FOR THE AIR RELEASE VALVE DETAIL.
8. EXISTING CATCH BASINS AND STORM SEWER PIPES, AFFECTED BY THE WORK, MAY HAVE TO BE REMOVED AND REPLACED TO ACCOMMODATE THE PIPE INSTALLATION.

CONSTRUCTION NOTES:

1. INSTALL 54-INCH MANHOLE, SEE 1/C501.
2. INSTALL 24-INCH HDPE (OR PVC) PIPE, SEE 3/C502, 4/C502, AND 5/C502.
3. INSTALL 8-INCH HDPE FORCEMAIN, SEE 5/C502.
4. INSTALL TEMPORARY INLET PROTECTION, SEE 2/C500.
5. INSTALL INLET/OUTLET TEES TO POTENTIAL NTS STORMWATER TREATMENT AREA, SEE 6/M502.
6. INSTALL 2-INCH SPARE ELECTRICAL CONDUIT, SEE 4/C502, 5/C502, 7/C502, AND 8/C502.
7. INSTALL 6-INCH HDPE FORCEMAIN (SPARE FOR POTENTIAL FUTURE CONVEYANCE FROM NTS STORMWATER TREATMENT AREA TO EFFLUENT OUTFALL), SEE 4/C502, 5/C502, 7/C502, AND 8/C502.
8. INSTALL ELECTRICAL PULLBOX, SEE 7/E502.

20' 10' 0 20' 40'

SCALE IN FEET

									C293	C292	C291	C290
							C299	C298	C297	C296	C295	C294
					C307	C306	C305	C304	C303	C302	C301	C300
C333	C332			C317	C316	C315	C314	C313	C312	C311	C310	C309	C308
C331	C330	C329	C328	C327	C326	C325	C324	C323	C322	C321	C320	C319	C318

KEY PLAN
SCALE : NONE

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SYM	REVISION	BY	APPROVED	DATE	SYM	REVISION	BY	APPROVED	DATE
A	PHASE 2 RE-ROUTE STORMWATER LINES – 60% DESIGN	URS	CASTRO	04.29.11					
B	PHASE 2 RE-ROUTE STORMWATER LINES – 90% DESIGN	URS	CASTRO	05.27.11					
C	PHASE 2 RE-ROUTE STORMWATER LINES – 100% DESIGN	URS	CASTRO	06.24.11					

BOEING

ACCEPTABILITY
THIS DESIGN AND/OR SPECIFICATION IS APPROVED

APPROVED BY	DEPT.	DATE

DRAWN	STICKEL	06.24.11
CHECKED		
ENGINEER	CASTRO	06.24.11
CHECKED		
APPROVED		
APPROVED		

SUBTITLE: STORM AND SANITARY SEWER

TITLE: PHASE 2 RE-ROUTE STORMWATER LINES
NORTH BOEING FIELD

CIVIL MASTER COL. NBF

CURRENT REVISION: D | SYMBOL | DATE: 06.24.11

SHEET: C295

JOB NO. | COMP NO.

DWG NO. 3.YD-C295

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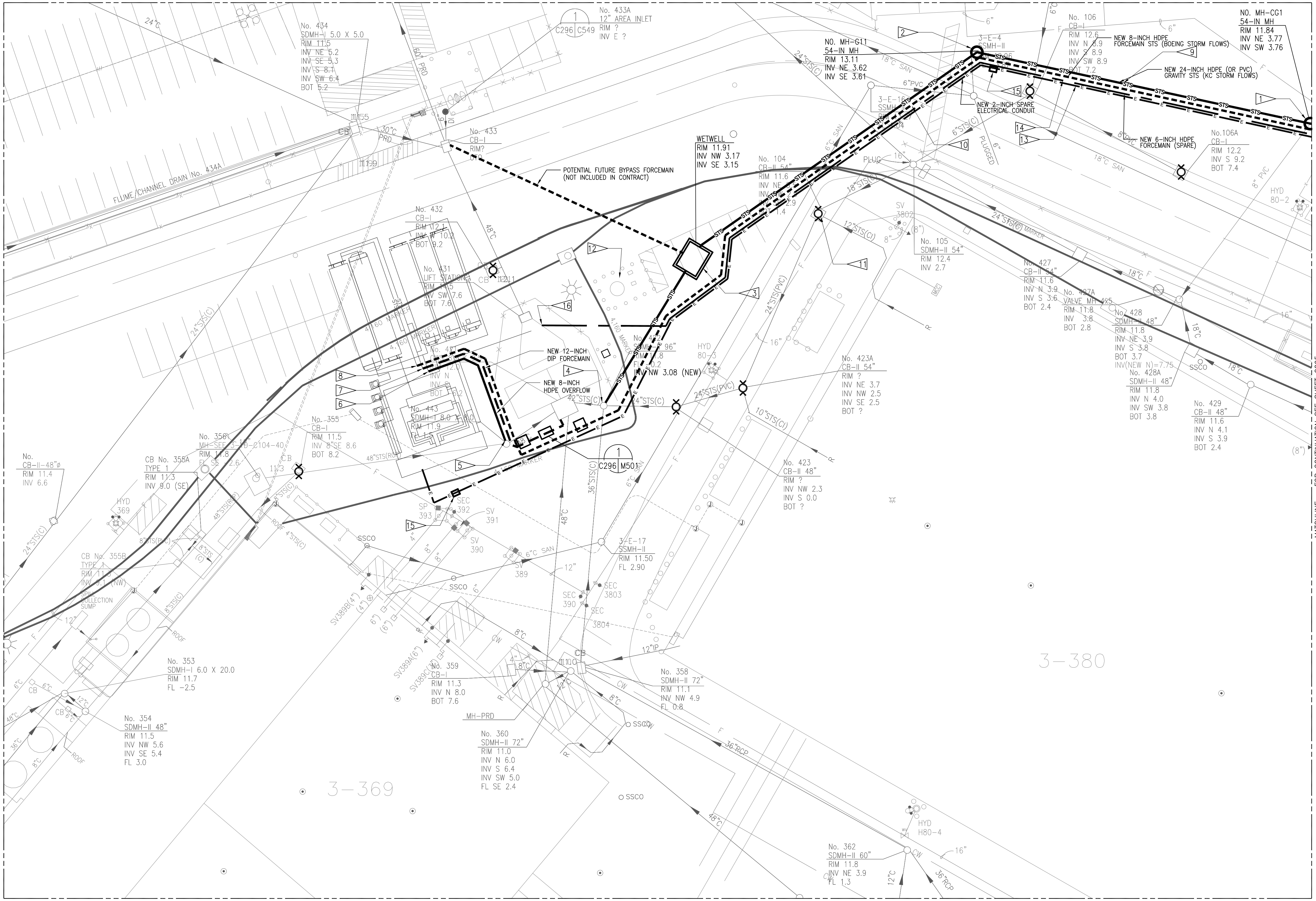
Mod: 06/24/2011, 11:29 | Plotted: 06/24/2011, 11:35 | larry_jiles



LEGEND:

- STS — STORM SEWER
- FORCEMAIN
- FORCEMAIN (SPARE LINE)
- E — ELECTRICAL CONDUIT
- TEMPORARY INLET PROTECTION, SEE 2/C500
- MANHOLE
- ELECTRICAL PULLBOX

GENERAL NOTES:

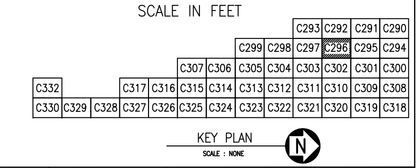
1. THE STORMWATER LINE SHOWN SHALL BE 24-INCH HDPE, SDR 17 OR PVC PIPE (PS46).
2. THE STORMWATER FORCEMAIN SHOWN SHALL BE 8-INCH HDPE, SDR 17.
3. THE OUTSIDE WALL OF THE 8-INCH STORMWATER FORCEMAIN SHALL BE A MINIMUM OF 12 INCHES FROM THE OUTSIDE WALL OF THE 24-INCH STORMWATER LINE.
4. THE RIM ELEVATION OF THE NEW MANHOLE AND WETWELL STRUCTURES SHALL BE SUCH THAT THE RIMS MATCH SURROUNDING GRADE.
5. UPON INSTALLING MANHOLE MH-CG1, CUT EXISTING 8-INCH PVC PIPE, WITHIN THE MANHOLE SECTION, TO AVOID CONFLICT WITH THE NEW 24-INCH HDPE (OR PVC) PIPE. CONNECT THE EXISTING 8-INCH PVC PIPE TO THE NEW MANHOLE AT THE INLET AND OUTLET ENDS USING KOR-N-SEAL OR APPROVED EQUAL. KEEP THE NEW 24-INCH HDPE (OR PVC) PIPE CONTINUOUS THROUGH THE NEW 54-INCH MANHOLE.
6. AT THE ENGINEER'S DIRECTION, PROVIDE AIR RELEASE VALVE ON 8-INCH HDPE FORCEMAIN AT ALL HIGH POINTS ON THE FORCEMAIN. SEE SHEET M503 FOR THE AIR RELEASE VALVE DETAIL.

CONSTRUCTION NOTES:

1. INSTALL 54-INCH MANHOLE, SEE 1/C501 AND NOTE 5.
2. INSTALL 54-INCH MANHOLE, SEE 1/C501.
3. INSTALL 12-FOOT X 10-FOOT X 12.85-FOOT I.D. CONCRETE WETWELL, SEE 1/M503.
4. CONNECT NEW 24-INCH HDPE (OR PVC) TO EXISTING MH 422, USE KOR-N-SEAL OR APPROVED EQUAL TO COMPLETE THE PIPE-TO-MANHOLE CONNECTION.
5. CONNECT NEW 8-INCH HDPE OVERFLOW FROM LTST TO EXISTING MH 443.
6. CONNECT NEW 8-INCH HDPE OVERFLOW TO LTST, SEE 3/M502.
7. CONNECT NEW 12-INCH DIP FORCEMAIN, FROM VALVE VAULT, TO LTST, SEE 3/M502.
8. CONNECT NEW 8-INCH HDPE FORCEMAIN, FROM MH 130A TO LTST, SEE 3/M502.
9. INSTALL 24-INCH HDPE (OR PVC) PIPE, SEE 4/C502.
10. INSTALL 8-INCH HDPE FORCEMAIN, SEE 4/C502.
11. INSTALL TEMPORARY INLET PROTECTION, SEE 2/C500.
12. DEMOLISH, REMOVE, AND DISPOSE OF THE FOLLOWING:
    - 16 STEEL BOLLARDS;
    - 18-INCH THICK CONCRETE PAD 12 FEET BY 20 FEET;
    - 6-FOOT DIAMETER BY 15 FEET TALL METAL TANK (NITROGEN) AND ASSOCIATED METAL STAND;
    - FOUR METAL EVAPORATIVE COILS; AND

    RESTORE ASPHALT CONCRETE PAVEMENT IN THE AREAS AFFECTED BY THE WORK IN-KIND OR BETTER.
13. INSTALL 2-INCH SPARE ELECTRICAL CONDUIT, SEE 4/C502, 5/C502, 7/C502, AND 8/C502.
14. INSTALL 6-INCH HDPE FORCEMAIN (SPARE FOR POTENTIAL FUTURE CONVEYANCE FROM NTS STORMWATER TREATMENT AREA TO EFFLUENT OUTFALL), SEE 4/C502, 5/C502, 7/C502, AND 8/C502.
15. INSTALL ELECTRICAL PULLBOX, SEE 7/E502.
16. INSTALL FORCEMAIN STUB, SEE 4/M503.

SCALE IN FEET: 20' 10' 0 20' 40'



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SYM	REVISION	BY	APPROVED	DATE	SYM	REVISION	BY	APPROVED	DATE
A	PHASE 2 RE-ROUTE STORMWATER LINES – 60% DESIGN	URS	CASTRO	04.29.11					
B	PHASE 2 RE-ROUTE STORMWATER LINES – 90% DESIGN	URS	CASTRO	05.27.11					
C	PHASE 2 RE-ROUTE STORMWATER LINES – 100% DESIGN	URS	CASTRO	06.24.11					

BOEING

ACCEPTABILITY
THIS DESIGN AND/OR SPECIFICATION IS APPROVED

APPROVED BY	DEPT.	DATE

		DATE
DRAWN	STICKEL	06.24.11
CHECKED		
ENGINEER	CASTRO	06.24.11
CHECKED		
APPROVED		
APPROVED		

SUBTITLE: STORM AND SANITARY SEWER

TITLE: PHASE 2 RE-ROUTE STORMWATER LINES
NORTH BOEING FIELD

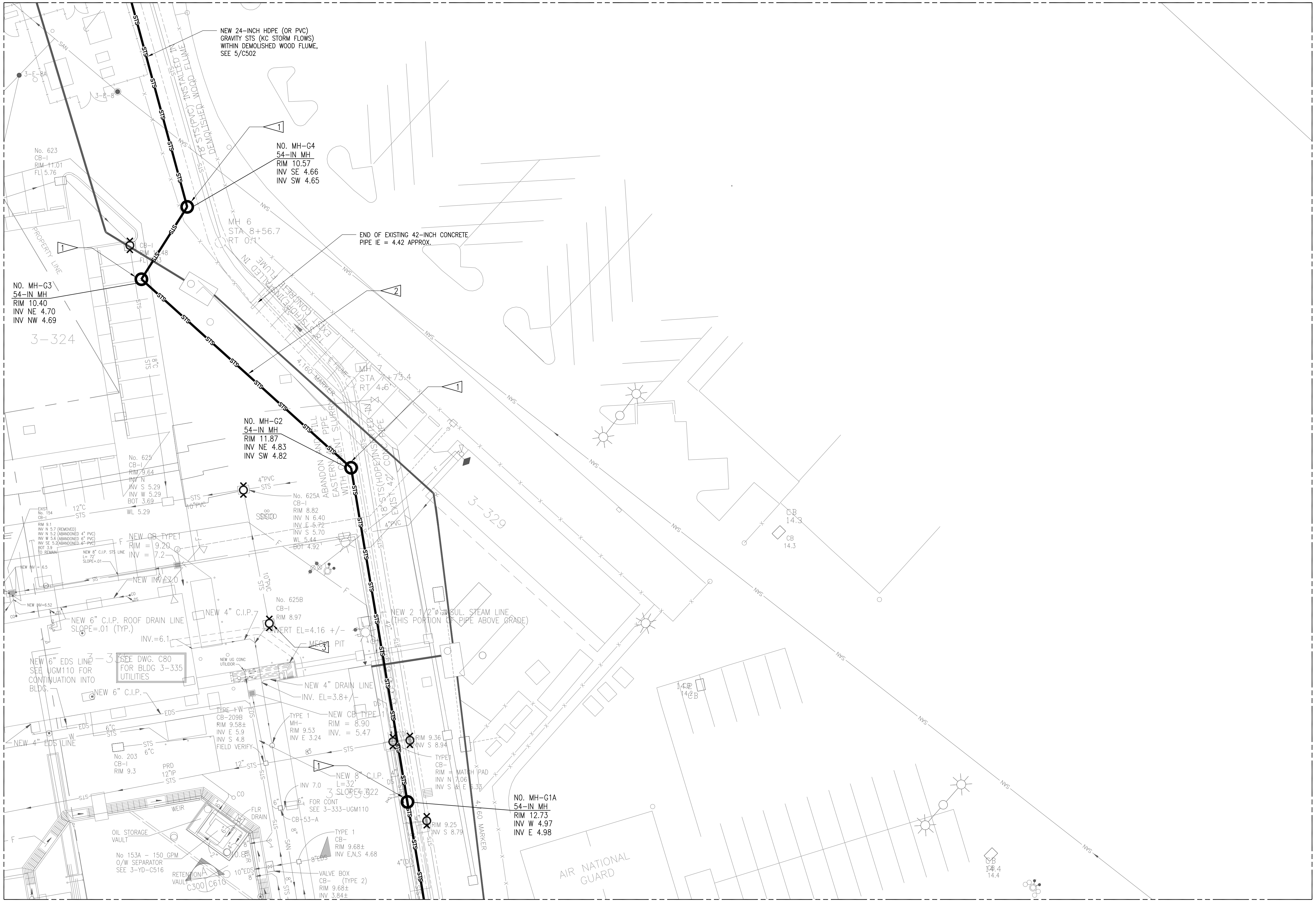
CIVIL MASTER COL. NBF

CURRENT REVISION SYMBOL: D
DATE: 06.24.11
SHEET: C296
JOB NO.
COMP NO.
DWG NO.: 3.YD-C296

Mod: 06/24/2011, 11:30 | Plotted: 06/24/2011, 11:36 | larry_jiles
O:\Boeing\NBF\PEL Remediation\Phase 2 Re-Route Storm Lines\R03\Civil\3-YD-C296 - Storm Align Plan.dwg

MATCHLINE – FOR CONTINUATION SEE SHEET C294

MATCHLINE – FOR CONTINUATION SEE SHEET C301



MATCHLINE – FOR CONTINUATION SEE SHEET C308

LEGEND:

- STS — STORM SEWER
- FORCEMAIN
- TEMPORARY INLET PROTECTION, SEE 2/C500
- MANHOLE

GENERAL NOTES:

1. THE STORMWATER LINE SHOWN SHALL BE 24-INCH HDPE, SDR 17 OR PVC PIPE (PS46).
2. BEGINNING AT MANHOLE MH-G1 (SHEET C308) AND ENDING DOWNGRADIENT OF MH-G2, INSTALL THE 24-INCH STORMWATER LINE INSIDE THE EXISTING 42-INCH CONCRETE PIPE IN ACCORDANCE WITH DETAIL 6 ON SHEET C502.
3. DOWNGRADIENT OF THE END OF THE EXISTING 42-INCH CONCRETE PIPE, AND TO THE EXTENT POSSIBLE, THE ALIGNMENT OF THE 24-INCH STORMWATER LINE FOLLOWS THE ALIGNMENT OF THE DEMOLISHED WOOD FLUME. THE WOOD FLUME WAS DEMOLISHED IN A PREVIOUS PROJECT. IT MAY BE NECESSARY TO REMOVE THE WALLS AND BOTTOM OF THE WOOD FLUME, IF PORTIONS STILL REMAIN, IN ORDER TO INSTALL THE 24-INCH STORMWATER LINE. THE WALL OF THE 24-INCH STORMWATER LINE SHALL BE A MINIMUM OF 12 INCHES FROM THE WALL OF THE EXISTING 18" STS LINE, WHICH WAS INSTALLED BY OTHERS WITHIN THE DEMOLISHED WOOD FLUME.
4. THE RIM ELEVATION OF THE NEW MANHOLE STRUCTURES SHALL BE SUCH THAT THE RIMS MATCH SURROUNDING GRADE.
5. DESIGN DRAWINGS FROM 1953 (BOEING AIRPLANE CO., SHEETS S64 AND S512) ARE THE SOURCE DRAWINGS FOR THE INVERT ELEVATIONS OF THE EXISTING 42-INCH CONCRETE PIPE. THE CONTRACTOR SHALL VERIFY THE INVERTS OF THE EXISTING 42-INCH CONCRETE PIPE AND NOTIFY THE OWNER IF THE INVERTS DIFFER FROM THE DESIGN.

CONSTRUCTION NOTES:

1. INSTALL 54-INCH MANHOLE, SEE 1/C501. REMOVE EXISTING 42-INCH CONCRETE PIPE AS REQUIRED.
2. INSTALL 24-INCH HDPE (OR PVC) PIPE, SEE 3/C502, 5/C502, AND 6/C502.
3. INSTALL TEMPORARY INLET PROTECTION, SEE 2/C500.

20' 10' 0 20' 40'
SCALE IN FEET

											C293	C292	C291	C290
								C299	C298	C297	C296	C295	C294	
					C307	C306	C305	C304	C303	C302	C301	C300		
C333	C332		C317	C316	C315	C314	C313	C312	C311	C310	C309	C308		
C331	C330	C329	C328	C327	C326	C325	C324	C323	C322	C321	C320	C319	C318	

KEY PLAN
SCALE : NONE

URS
1501 4TH AVENUE, STE. 1400
SEATTLE, WA 98101-1616
TELEPHONE (206) 438-2700

SYM	REVISION	BY	APPROVED	DATE
A	PHASE 2 RE-ROUTE STORMWATER LINES – 60% DESIGN	URS	CASTRO	04.29.11
B	PHASE 2 RE-ROUTE STORMWATER LINES – 90% DESIGN	URS	CASTRO	05.27.11
C	PHASE 2 RE-ROUTE STORMWATER LINES – 100% DESIGN	URS	CASTRO	06.24.11

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ACCEPTABILITY
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APPROVED BY | DEPT. | DATE

DRAWN	STICKEL	06.24.11
CHECKED		
ENGINEER	CASTRO	06.24.11
CHECKED		
APPROVED		
APPROVED		

SUBTITLE: STORM AND SANITARY SEWER

TITLE: PHASE 2 RE-ROUTE STORMWATER LINES
NORTH BOEING FIELD

CIVIL MASTER COL. NBF

CURRENT REVISION: SYMBOL D
DATE: 06.24.11
SHEET: C300
JOB NO.
COMP NO.
DWG NO.: 3.YD-C300

Mod: 06/24/2011, 11:32 | Plotted: 06/24/2011, 11:36 | larry_files

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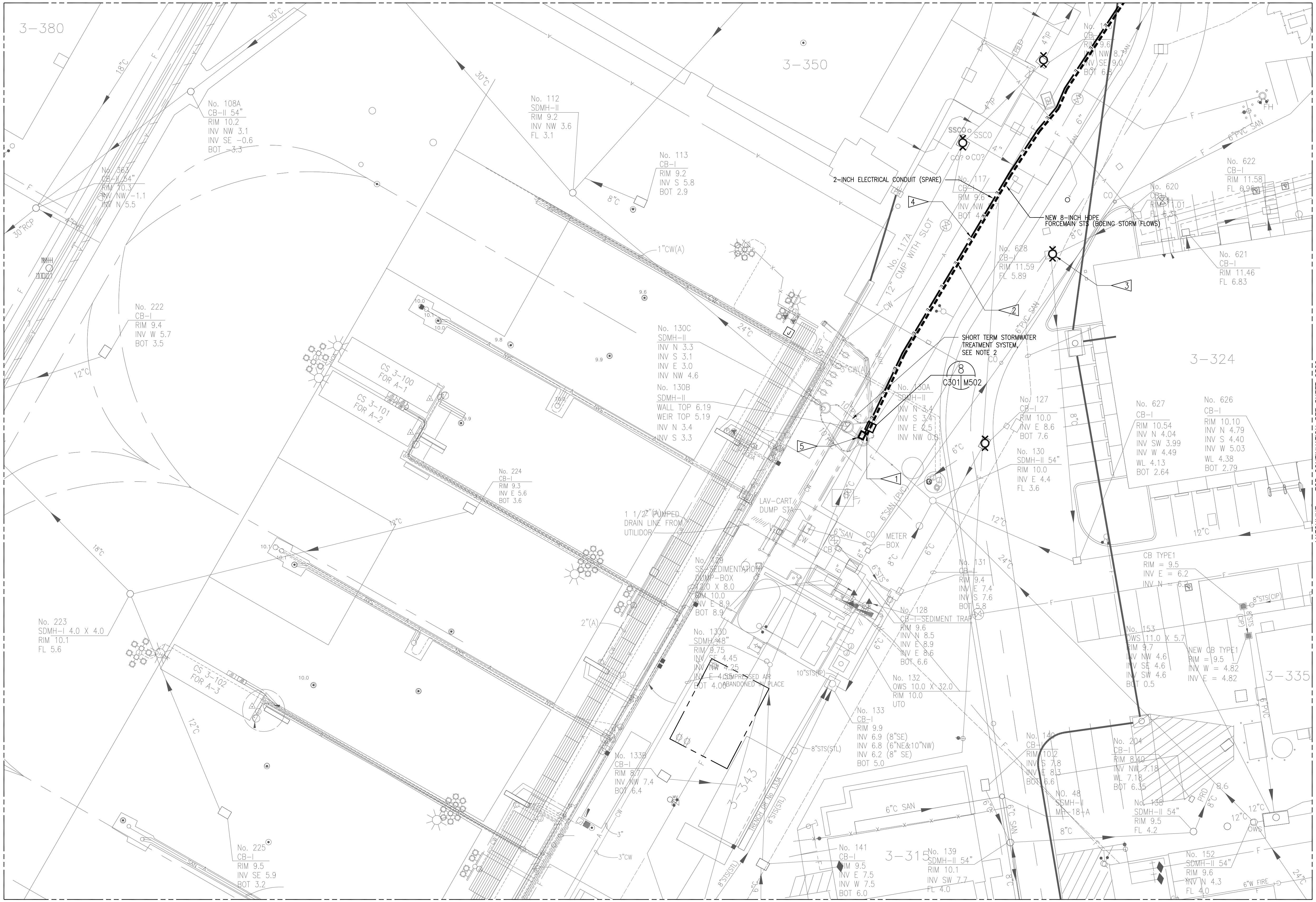


LEGEND:

- STS — STORM SEWER
- FORCEMAIN
- FORCEMAIN (SPARE LINE)
- E — ELECTRICAL CONDUIT
- TEMPORARY INLET PROTECTION, SEE 2/C500
- MANHOLE
- ELECTRICAL PULLBOX

GENERAL NOTES:

1. THE STORMWATER FORCEMAIN SHALL BE 8-INCH HDPE, SDR 17.
2. EXISTING CONDITIONS OF THE SHORT TERM STORMWATER TREATMENT SYSTEM WERE PROVIDED BY LANDAU ASSOCIATES, INC.
3. THE RIM ELEVATION OF THE NEW MANHOLE AND VALVE VAULT STRUCTURES SHALL BE SUCH THAT THE RIMS MATCH SURROUNDING GRADE.
4. AT THE ENGINEER'S DIRECTION, PROVIDE AIR RELEASE VALVE ON 8-INCH HDPE FORCEMAIN AT ALL HIGH POINTS ON THE FORCEMAIN. SEE SHEET M503 FOR THE AIR RELEASE VALVE DETAIL.

CONSTRUCTION NOTES:

1. CONNECT NEW 8-INCH HDPE FORCEMAIN TO EXISTING MH 130A.
2. INSTALL 8-INCH HDPE FORCEMAIN, SEE 3/C502.
3. INSTALL TEMPORARY INLET PROTECTION, SEE 2/C500.
4. INSTALL 2-INCH SPARE ELECTRICAL CONDUIT, SEE 7/C502.
5. INSTALL ELECTRICAL PULLBOX, SEE 7/E502.

20' 10' 0 20' 40'

SCALE IN FEET

											C293	C292	C291	C290
									C299	C298	C297	C296	C295	C294
					C307	C306	C305	C304	C303	C302	C301	C300		
C333	C332		C317	C316	C315	C314	C313	C312	C311	C310	C309	C308		
C331	C330	C329	C328	C327	C326	C325	C324	C323	C322	C321	C320	C319	C318	

KEY PLAN
SCALE : NONE

URS 1501 4TH AVENUE, STE. 1400 SEATTLE, WA 98101-1616 TELEPHONE (206) 438-2700

SYM	REVISION	BY	APPROVED	DATE
A	PHASE 2 RE-ROUTE STORMWATER LINES – 60% DESIGN	URS	CASTRO	04.29.11
B	PHASE 2 RE-ROUTE STORMWATER LINES – 90% DESIGN	URS	CASTRO	05.27.11
C	PHASE 2 RE-ROUTE STORMWATER LINES – 100% DESIGN	URS	CASTRO	06.24.11

BOEING

ACCEPTABILITY
THIS DESIGN AND/OR SPECIFICATION IS APPROVED
APPROVED BY | DEPT. | DATE

DRAWN: STICKEL 06.24.11
CHECKED
ENGINEER: CASTRO 06.24.11
CHECKED
APPROVED
APPROVED

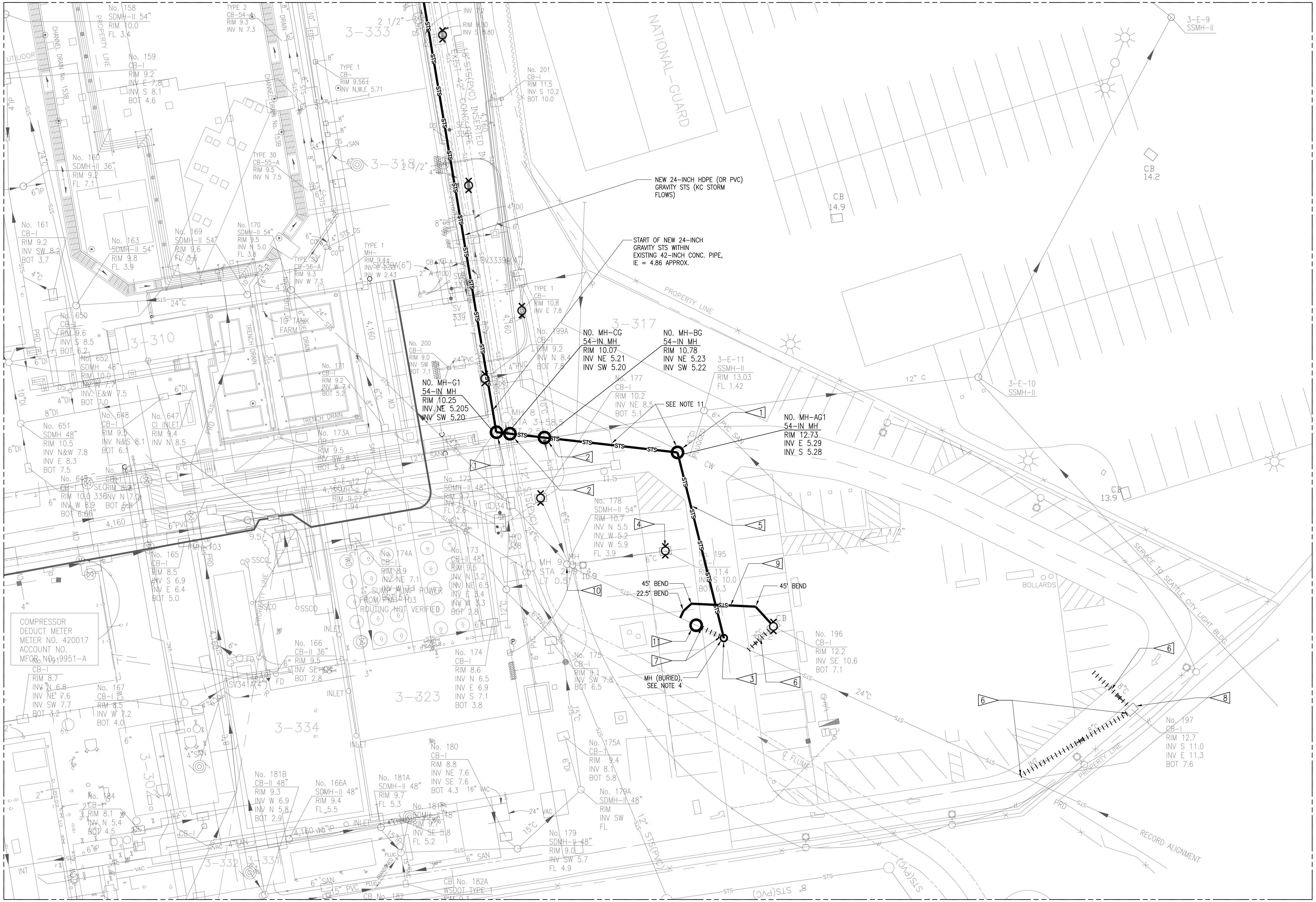
SUBTITLE: STORM AND SANITARY SEWER
TITLE: PHASE 2 RE-ROUTE STORMWATER LINES
NORTH BOEING FIELD

CIVIL MASTER COL. NBF

CURRENT REVISION | SYMBOL D | DATE 06.24.11
SHEET C301
JOB NO. | COMP NO.
DWG NO. 3.YD-C301

Mod: 06/23/2011, 13:26 | Plotted: 06/24/2011, 11:37 | larry_liles
O:\Boeing\NBF\PEL Remediation\Phase 2 Re-Route Storm Lines\R03\Civil\3-YD-C301 - Storm Align Plan.dwg

MATCHLINE – FOR CONTINUATION SEE SHEET C300



LEGEND:

STS — STORM SEWER

ABANDON AND FILL AND PLUG STORMWATER PIPE

TEMPORARY INLET PROTECTION, SEE 2/C500

MANHOLE

GENERAL NOTES:

1. THE STORMWATER LINE SHOWN SHALL BE 24-INCH HDPE, SDR 17 OR PVC PIPE (PS46).
2. BEGINNING AT MANHOLE MH-G1 AND ENDING DOWNGRADIENT OF MH-G2 (SHEET C300), INSTALL THE 24-INCH STORMWATER LINE INSIDE THE EXISTING 42-INCH CONCRETE PIPE IN ACCORDANCE WITH DETAIL 6 ON SHEET C502.
3. DESIGN DRAWINGS FROM 1953 (BOEING AIRPLANE CO., SHEETS S64 AND S512) ARE THE SOURCE DRAWINGS FOR THE INVERT ELEVATIONS OF THE EXISTING 42-INCH CONCRETE PIPE. THE CONTRACTOR SHALL VERIFY THE INVERTS OF THE EXISTING 42-INCH CONCRETE PIPE AND NOTIFY THE OWNER IF THE INVERTS DIFFER FROM THE DESIGN.
4. THE BURIED MANHOLE WAS LOCATED USING TELEVISION INSPECTION RESULTS PERFORMED BY BRAVO ENVIRONMENTAL ON AUGUST 5, 2010. THE BURIED MANHOLE IS STATED TO BE 73.51 FEET UPGRADIENT OF MANHOLE MH-178. THIS MANHOLE IS THE POINT OF SPLIT BETWEEN STORMWATER FLOWS FROM KING COUNTY/NATIONAL GUARD AND BOEING.
5. THE RIM ELEVATION OF THE NEW MANHOLE STRUCTURES SHALL BE SUCH THAT THE RIMS MATCH SURROUNDING GRADE.
6. ABANDON AND FILL AND PLUG EXISTING 6-INCH AND 8-INCH STORMWATER PIPES IN ACCORDANCE WITH THE 2011 CITY OF SEATTLE STANDARD SPECIFICATIONS 2-02.3(5).
7. ABANDON AND FILL AND PLUG EXISTING 24-INCH STORMWATER PIPE, UPGRADIENT OF THE CONNECTION POINT WITH THE NEW INSERTA TEE FITTING AND ENDING AT THE BLIND MANHOLE IN ACCORDANCE WITH THE 2011 CITY OF SEATTLE STANDARD SPECIFICATIONS 2-02.3(5).
8. UPON INSTALLING MANHOLE MH-BG, CUT EXISTING 10-INCH CONCRETE PIPE, WITHIN THE MANHOLE SECTION, TO AVOID CONFLICT WITH THE NEW 24-INCH STORMWATER PIPE. CONNECT THE EXISTING 10-INCH CONCRETE PIPE TO THE NEW MANHOLE AT THE INLET AND OUTLET ENDS USING KOR-N-SEAL OR APPROVED EQUAL. KEEP THE NEW 24-INCH STORMWATER PIPE CONTINUOUS THROUGH THE NEW 54-INCH MANHOLE.
9. UPON INSTALLING MANHOLE MH-CG, CUT EXISTING 12-INCH PVC PIPE, WITHIN THE MANHOLE SECTION, TO AVOID CONFLICT WITH THE NEW 24-INCH STORMWATER PIPE. CONNECT THE EXISTING 12-INCH PVC PIPE TO THE NEW MANHOLE AT THE INLET AND OUTLET ENDS USING KOR-N-SEAL OR APPROVED EQUAL. KEEP THE NEW 24-INCH STORMWATER PIPE CONTINUOUS THROUGH THE NEW 54-INCH MANHOLE.
10. WHEN ABANDONING AND FILLING AND PLUGGING EXISTING PIPES WITH FLOWABLE CEMENT SLURRY AND CONCRETE, CARE SHALL BE TAKEN TO KEEP PIPES, CATCH BASINS, AND MANHOLES, WHICH ARE TO REMAIN IN SERVICE, CLEAR OF SLURRY AND CONCRETE. CONTRACTOR SHALL CLEAN OUT PIPES, CATCH BASINS, AND MANHOLES THAT ARE AFFECTED BY THE WORK.
11. THERE IS A POTENTIAL CONFLICT BETWEEN THE NEW 24-INCH STORMWATER PIPE AND AN EXISTING 4,160V ELECTRICAL LINE AND COLD WATER LINE. IF A CONFLICT IS DISCOVERED, NOTIFY THE OWNER IMMEDIATELY.

CONSTRUCTION NOTES:

1. INSTALL 54-INCH MANHOLE, SEE 1/C501.
2. INSTALL 54-INCH MANHOLE, SEE 1/C501 AND NOTES 8 AND 9.
3. CONNECT NEW 24-INCH HDPE (OR PVC) TO EXISTING BURIED MH, IE (W) = 5.37, USE KOR-N-SEAL OR APPROVED EQUAL TO COMPLETE THE PIPE-TO-MANHOLE CONNECTION.
4. INSTALL TEMPORARY INLET PROTECTION, SEE 2/C500.
5. INSTALL 24-INCH HDPE (OR PVC) PIPE, SEE 3/C502 AND 6/C502.
6. ABANDON AND FILL AND PLUG EXISTING 6-INCH AND 8-INCH CONCRETE PIPES, SEE NOTES 6 AND 10.
7. ABANDON AND FILL AND PLUG EXISTING 24-INCH CONCRETE PIPE, SEE NOTES 7 AND 10.
8. AT CATCH BASIN NO. 197:
   - REMOVE CATCH BASIN GRATE AND FRAME;
   - BACKFILL CATCH BASIN STRUCTURE WITH CONTROLLED DENSITY FILL, IN ACCORDANCE WITH THE 2011 CITY OF SEATTLE STANDARD SPECIFICATIONS 2-10.2(3)A2 FOR "TRENCH BACKFILL CDF"; AND
   - RESTORE ASPHALT CONCRETE PAVEMENT IN-KIND OR BETTER.
9. INSTALL 6-INCH HDPE PIPE, SEE 3/C502.
   - AT UPGRADIENT END OF PIPE CONNECT TO EXISTING CATCH BASIN NO. 196 USING KOR-N-SEAL OR APPROVED EQUAL AT IE (SW)=10.6.; AND
   - AT DOWNGRADIENT END OF PIPE CONNECT TO EXISTING 24-INCH CONCRETE PIPE USING INSERTA TEE FITTING MODEL NO. 6IPS24CC, AS MANUFACTURED BY INSERTA FITTINGS CO., OR APPROVED EQUAL.
10. CAREFULLY REMOVE THE SEDIMENT TRAP BOTTLE SUPPORTS (2 EACH) AND ASSOCIATED WEIR PLATE FROM MH NO. 178 AND REINSTALL THESE ITEMS IN THE BURIED MANHOLE OR AT AN ALTERNATIVE LOCATION THAT THE OWNER WILL IDENTIFY, FOLLOWING COMPLETION OF THE 24-INCH STORM SEWER PIPING INSTALLATION.
11. INSTALL 54-INCH MANHOLE, SEE 1/C501. REMOVE EXISTING STORM SEWER TO INSTALL MANHOLE AND CONNECT EXISTING STORM SEWER TO MANHOLE USING KOR-N-SEAL.

20' 10' 0 20' 40'

SCALE IN FEET

										C293	C292	C291	C290
								C299	C298	C297	C296	C295	C294
						C307	C306	C305	C304	C303	C302	C301	C300
C333	C332			C317	C316	C315	C314	C313	C312	C311	C310	C309	C308
C331	C330	C329	C328	C327	C326	C325	C324	C323	C322	C321	C320	C319	C318

KEY PLAN
SCALE : NONE

URS 1501 4TH AVENUE, STE. 1400 SEATTLE, WA 98101-1616 TELEPHONE (206) 438-2700

SYM	REVISION	BY	APPROVED	DATE
A	PHASE 2 RE-ROUTE STORMWATER LINES – 60% DESIGN	URS	CASTRO	04.29.11
B	PHASE 2 RE-ROUTE STORMWATER LINES – 90% DESIGN	URS	CASTRO	05.27.11
C	PHASE 2 RE-ROUTE STORMWATER LINES – 100% DESIGN	URS	CASTRO	06.24.11

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ACCEPTABILITY
THIS DESIGN AND/OR SPECIFICATION IS APPROVED

APPROVED BY | DEPT. | DATE

DRAWN: STICKEL — DATE 06.24.11
CHECKED
ENGINEER: CASTRO — 06.24.11
CHECKED
APPROVED
APPROVED

SUBTITLE: STORM AND SANITARY SEWER

TITLE: PHASE 2 RE-ROUTE STORMWATER LINES
NORTH BOEING FIELD

CIVIL MASTER — COL. — NBF

CURRENT REVISION — SYMBOL: D — DATE: 06.24.11

SHEET: C308

JOB NO. — COMP NO.

DWG NO.: 3.YD-C308

Mod: 06/24/2011, 11:34 | Plotted: 06/24/2011, 11:37 | larry_jiles

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LEGEND:

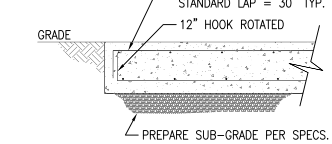
CONCRETE PAD

GENERAL NOTES:

1. REFER TO LANDAU ASSOCIATES DRAWINGS FOR DETAILS OF THE LONG-TERM STORMWATER TREATMENT SYSTEM.
2. PRIOR TO CONSTRUCTING CONCRETE MAT SLABS, SAWCUT EXISTING ASPHALT CONCRETE PAVEMENT. FOLLOWING SLABS CONSTRUCTION, RESTORE THE AREAS AFFECTED BY THE WORK TO PRE-PROJECT CONDITION OR BETTER.
3. CONTRACTOR TO VERIFY DIMENSIONS PROVIDED BASED ON MINIMUM 12" CLEARANCE AROUND EQUIPMENT PER EQUIPMENT MANUFACTURER.

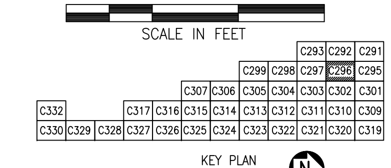
CONSTRUCTION NOTES:

1 CONSTRUCT 12-INCH THICK CONCRETE MAT SLAB WITH #6 BARS @ 12 INCHES O.C. EACH WAY TOP AND BOTTOM, SEE NOTE 2. SLOPE TOP OF SLAB TO MATCH TOP OF EXISTING ADJACENT GRADE.



10' 5' 0 10' 20'

SCALE IN FEET



KEY PLAN
SCALE : NONE

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SYM	REVISION	BY	APPROVED	DATE	SYM	REVISION	BY	APPROVED	DATE
A	PHASE 2 RE-ROUTE STORMWATER LINES – 60% DESIGN	URS	FRANCO	04.29.11					
B	PHASE 2 RE-ROUTE STORMWATER LINES – 90% DESIGN	URS	FRANCO	05.27.11					
C	PHASE 2 RE-ROUTE STORMWATER LINES – 100% DESIGN	URS	FRANCO	06.24.11					

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ACCEPTABILITY
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APPROVED BY	DEPT.	DATE

DRAWN	MUENCH	DATE 06.24.11
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ENGINEER	FRANCO	06.24.11
CHECKED		
APPROVED		
APPROVED		

SUBTITLE: ENLARGED PAVING PLAN

TITLE: PHASE 2 RE-ROUTE STORMWATER LINES
NORTH BOEING FIELD

CIVIL MASTER COL. NBF

CURRENT REVISION | SYMBOL D | DATE 06.24.11

SHEET C450

JOB NO. | COMP NO.

DWG NO. 3.YD-C450

Mod: 06/22/2011, 13:48 | Plotted: 06/24/2011, 10:40 | larry_jiles

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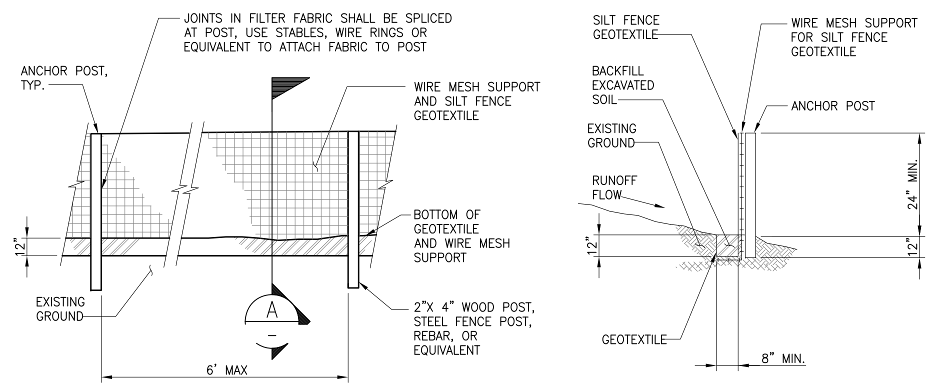
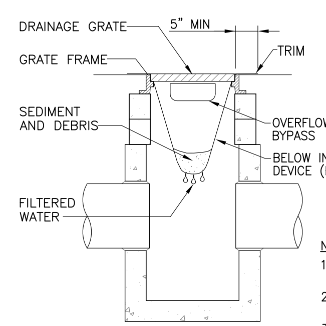


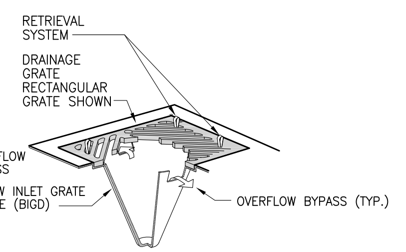
ELEVATION

SECTION A

SILT FENCE DETAIL 1

SCALE: N.T.S.





NOTES:

1. SIZE THE BELOW INLET GRATE DEVICE (BIGD) FOR THE STORM WATER STRUCTURE IT WILL SERVICE.
2. THE BIGD SHALL HAVE A BUILT-IN HIGH-FLOW RELIEF SYSTEM (OVERFLOW BYPASS).
3. THE RETRIEVAL SYSTEM MUST ALLOW REMOVAL OF THE BIGD WITHOUT SPILLING THE COLLECTED MATERIAL.
4. PERFORM MAINTENANCE IN ACCORDANCE WITH STANDARD SPECIFICATION WSDOT 8-01.3(15).

TEMPORARY INLET PROTECTION DETAIL 2

SCALE: N.T.S.

TESC NOTES

1. THROUGHOUT THE DURATION OF THE PROJECT, THE CONTRACTOR SHALL PROVIDE POSITIVE DRAINAGE TO ALL DISTURBED AREAS AND CONTROL THE QUALITY OF THE EFFLUENT RUNOFF.
2. THE IMPLEMENTATION OF ESC MEASURES SHOWN ON THE PLANS AND THE CONSTRUCTION, MAINTENANCE, REPLACEMENT, AND UPGRADING OF THESE ESC FACILITIES IS THE RESPONSIBILITY OF THE CONTRACTOR UNTIL WORK IS COMPLETED AND APPROVED OR IS DETERMINED TO BE NO LONGER REQUIRED BY THE CONSTRUCTION MANAGER.
3. ESC FACILITIES SHOWN ON THE PLANS SHALL BE CONSTRUCTED PRIOR TO ANY EARTH-DISTRUBING SO AS TO ENSURE THAT THE TRANSPORT OF SEDIMENT TO SURFACE WATERS, DRAINAGE SYSTEMS, AND ADJACENT PROPERTIES IS MINIMIZED.
4. ESC FACILITIES SHOWN ON THE PLANS ARE THE MINIMUM REQUIREMENTS FOR ANTICIPATED SITE CONDITIONS. DURING THE CONSTRUCTION PERIOD, THESE ESC FACILITIES SHALL BE UPGRADED AS NEEDED FOR UNEXPECTED STORM EVENTS AND MODIFIED TO ACCOUNT FOR CHANGING SITE CONDITIONS (E.G., ADDITIONAL TEMPORARY INLET PROTECTION, ADDITIONAL SILT FENCE, ETC.).
5. THE BOUNDARIES OF THE CONSTRUCTION LIMITS SHOWN ON THESE PLANS SHALL BE CLEARLY FLAGGED IN THE FIELD PRIOR TO CONSTRUCTION. DURING THE CONSTRUCTION PERIOD, NO DISTURBANCE BEYOND THE FLAGGED CONSTRUCTION LIMITS SHALL BE PERMITTED. THE FLAGGING SHALL BE MAINTAINED BY THE CONTRACTOR FOR THE DURATION OF CONSTRUCTION.
6. TEMPORARY INLET PROTECTION SHALL BE PROVIDED IN ALL EXISTING CATCH BASINS WITHIN THE CONSTRUCTION LIMITS.
7. ANY AREAS OF EXPOSED SOILS THAT WILL NOT BE DISTURBED FOR TWO DAYS DURING THE WET SEASON OR SEVEN DAYS DURING THE DRY SEASON SHALL BE IMMEDIATELY STABILIZED WITH THE APPROVED ESC METHODS (SEEDING, MULCHING, PLASTIC COVERING, ETC.).
8. ANY AREAS NEEDING ESC MEASURES NOT REQUIRING IMMEDIATE ATTENTION SHALL BE ADDRESSED WITHIN FIFTEEN (15) DAYS.
9. THE ESC FACILITIES SHALL BE INSPECTED DAILY BY THE CONTRACTOR AND MAINTAINED AS NECESSARY TO ENSURE THEIR CONTINUED FUNCTIONING.
10. THE ESC FACILITIES ON INACTIVE SITES SHALL BE INSPECTED AND MAINTAINED A MINIMUM OF ONCE A MONTH OR WITHIN FORTY-EIGHT (48) HOURS FOLLOWING A STORM EVENT.
11. AT NO TIME SHALL MORE THAN ONE (1) FOOT OF SEDIMENT BE ALLOWED TO ACCUMULATE WITHIN A CATCH BASIN. ALL CATCH BASINS AND CONVEYANCE LINES SHALL BE CLEANED PRIOR TO PROJECT COMPLETION. THE CLEANING OPERATION SHALL NOT FLUSH SEDIMENT-LADEN WATER INTO THE DOWNSTREAM SYSTEM. ALL LIQUIDS AND SEDIMENTS REMOVED FROM CATCH BASINS MUST BE TAKEN OFFSITE FOR DISPOSAL.
12. STRAW MULCH UTILIZATION IS NOT ANTICIPATED. IF STRAW MULCH BECOMES NECESSARY OR REQUIRED, IT SHALL BE APPLIED AT A MINIMUM THICKNESS OF 2 TO 3 INCHES.
13. THE STREET SURFACE SHALL BE CLEANED AT THE END OF EACH DAY'S OPERATION WITH A POWER BROOM OR OTHER APPROVED MEANS.
14. THE CONTRACTOR SHALL IMPLEMENT LINEAR RUN-ON CONTROLS TO PREVENT WATER FROM ENTERING THE CONSTRUCTION AREA.
15. THE CONTRACTOR SHALL COVER AND SECURE MATERIAL ON THE TRUCKS DURING OFFSITE TRAVEL IF NECESSARY TO PREVENT SPILLAGE OR LOSS OF MATERIAL.
16. PROCESS WATER, SUCH AS WATER USED IN CONCRETE WORK, SHALL BE HAULED TO AN APPROPRIATE DISPOSAL SITE. PROCESS WATER SHALL NOT BE DISCHARGED TO THE STORM DRAIN.
17. THE CONTRACTOR SHALL REFER TO "WASHINGTON STATE DEPARTMENT OF ECOLOGY, STORMWATER MANUAL FOR WESTERN WASHINGTON, FEBRUARY 2005" FOR REFERENCE TO NECESSARY EROSION AND SEDIMENT CONTROLS. THE FOLLOWING LIST CONTAINS SOME COMMON BMP PRACTICES, BUT ARE NOT LIMITED TO THE ONES LISTED BELOW. THE CONTRACTOR SHALL USE ANY APPROVED CONTROL METHODS REQUIRED PER SPECIFICATIONS.
    A. BMP C103: HIGH VISIBILITY PLASTIC FENCE
    B. BMP C123: PASTIC COVERING
    C. BMP C220: STORM DRAIN INLET PROTECTION
    D. BMP C230: STRAW BALE BARRIER
    E. BMP C233: SILT FENCE
    F. BMP C235: STRAW WATTLE
19. ALL STORMWATER RUNOFF FROM THE CONSTRUCTION SITE SHALL BE TREATED IN ORDER TO MEET PERMITTED DISCHARGE LIMITS PRIOR TO DISCHARGING TO THE STORM DRAIN AT THE POINT OF DISCHARGE SHOWN ON THE DRAWINGS.
20. CLEAN CATCH BASINS PRIOR TO INSTALLING TEMPORARY INLET PROTECTION. UPON COMPLETION OF THE PROJECT, REMOVE TEMPORARY INLET PROTECTION AND CLEAN CATCH BASINS.

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SEATTLE, WA 98101-1616
TELEPHONE (206) 438-2700

SYM	REVISION	BY	APPROVED	DATE	SYM	REVISION	BY	APPROVED	DATE
A	PHASE 2 RE-ROUTE STORMWATER LINES – 60% DESIGN	URS	CASTRO	04.29.11					
B	PHASE 2 RE-ROUTE STORMWATER LINES – 90% DESIGN	URS	CASTRO	05.27.11					
C	PHASE 2 RE-ROUTE STORMWATER LINES – 100% DESIGN	URS	CASTRO	06.24.11					

BOEING®

ACCEPTABILITY
THIS DESIGN AND/OR SPECIFICATION IS APPROVED

APPROVED BY	DEPT.	DATE

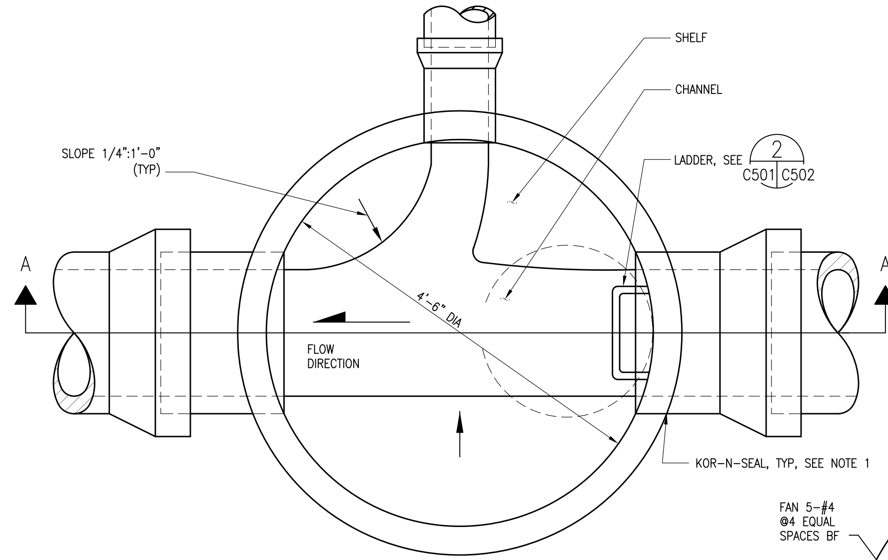
DRAWN STICKEL	DATE 06.24.11
CHECKED	
ENGINEER CASTRO	06.24.11
CHECKED	
APPROVED	
APPROVED	

SUBTITLE
SECTIONS AND DETAILS

TITLE
PHASE 2 RE-ROUTE STORMWATER LINES
NORTH BOEING FIELD

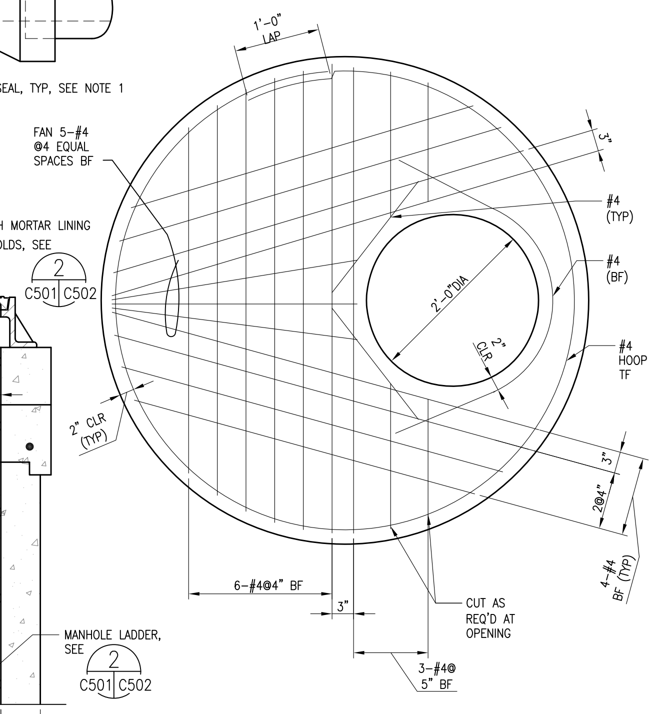
CIVIL MASTER COL. NBF

CURRENT REVISION	SYMBOL D	DATE 06.24.11
SHEET C500		
JOB NO.		COMP NO.
DWG NO. 3.YD-C500		

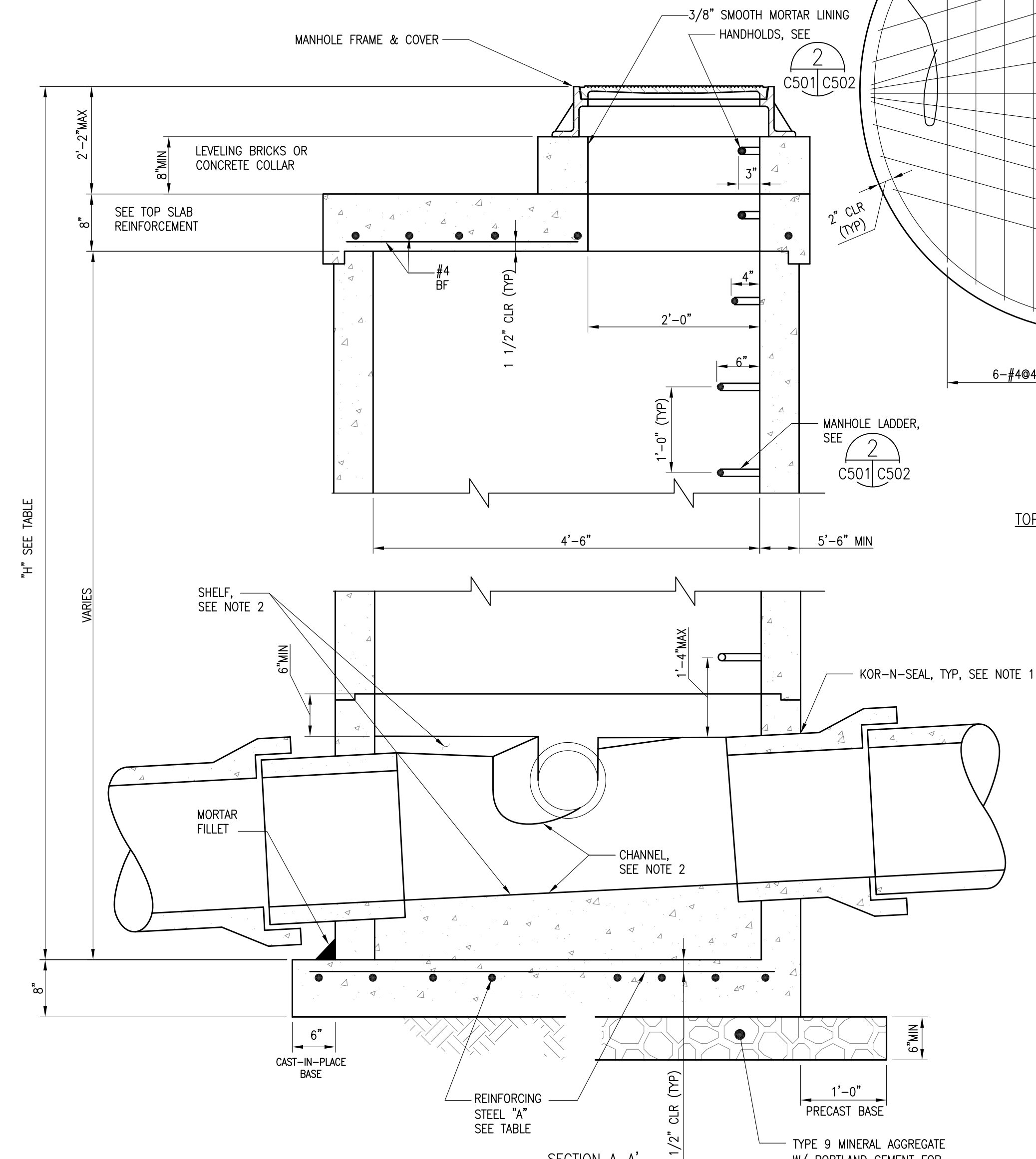


PLAN VIEW

"H"	REINFORCING STEEL "A" MIN SQ IN/FT, TOP FACE, IN EACH DIRECTION	
	PRECAST BASE	CAST-IN-PLACE BASE
20' MAX	0.29	0.21
30' MAX	0.36	0.26
40' MAX	0.42	0.31



TOP SLAB REINFORCEMENT



SECTION A-A'

NOTES:
1. USE KOR-N-SEAL MANHOLE-TO-PIPE CONNECTOR, 506 SERIES OR APPROVED EQUAL.
2. MH-CG1, MH-BG AND MH-CG SHALL NOT HAVE SHELF OR CHANNEL.

SOURCE:
CITY OF SEATTLE STANDARD PLAN NO. 204.5b (2011)

TYPICAL 54" MANHOLE 1 VAR C501
SCALE: N.T.S.

Mod: 06/22/2011, 14:01 | Plotted: 06/24/2011, 10:41 | larry_jiles
O:\Boeing\NBF\PEL Remediation\Phase 2 Re-Route Storm Lines\R03\Civil\3-YD-C501 - Manhole Details.dwg

URS 1501 4TH AVENUE, STE. 1400 SEATTLE, WA 98101-1616 TELEPHONE (206) 438-2700

SYM	REVISION	BY	APPROVED	DATE
A	PHASE 2 RE-ROUTE STORMWATER LINES – 60% DESIGN	URS	CASTRO	04.29.11
B	PHASE 2 RE-ROUTE STORMWATER LINES – 90% DESIGN	URS	CASTRO	05.27.11
C	PHASE 2 RE-ROUTE STORMWATER LINES – 100% DESIGN	URS	CASTRO	06.24.11

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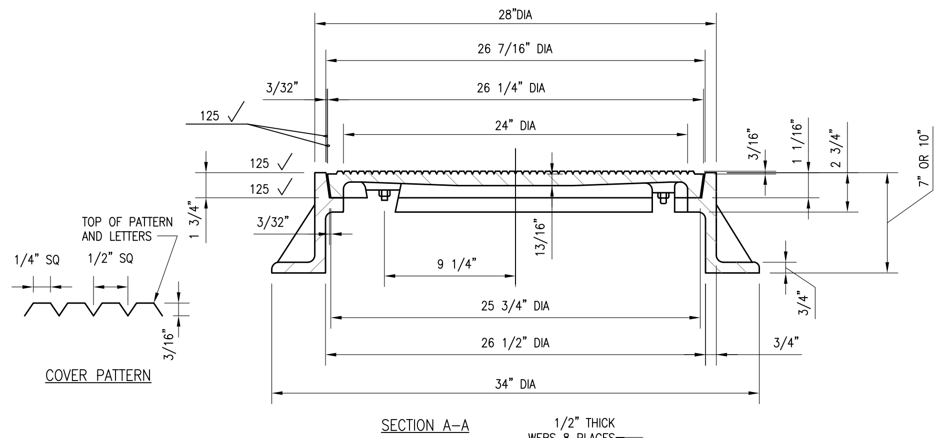
APPROVED BY | DEPT. | DATE

DRAWN	STICKEL	DATE 06.24.11
CHECKED		
ENGINEER	CASTRO	06.24.11
CHECKED		
APPROVED		
APPROVED		

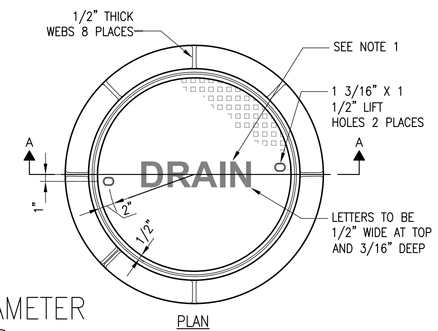
SUBTITLE: SECTION AND DETAILS
TITLE: PHASE 2 RE-ROUTE STORMWATER LINES
NORTH BOEING FIELD
CIVIL MASTER COL. NBF

CURRENT REVISION | SYMBOL D | DATE 06.24.11
SHEET C501
JOB NO. | COMP NO.
DWG NO. 3.YD-C501



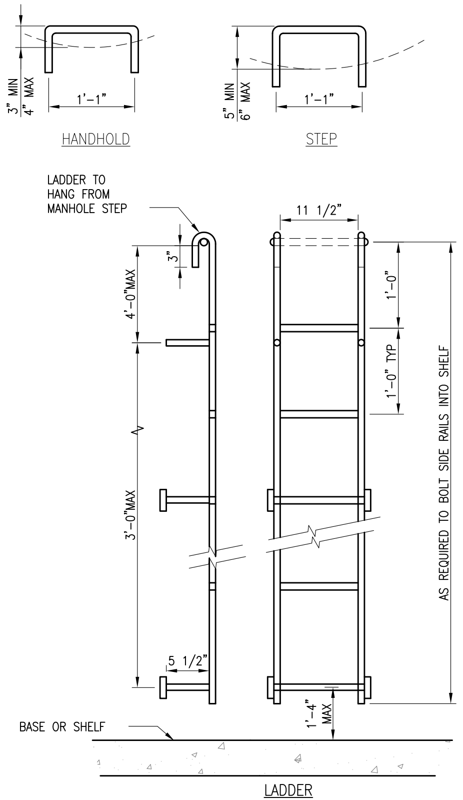
NOTES:
1. "DRAIN" SHALL BE 3" RAISED LETTERS.
2. COVER THICKNESS IS MEASURED FROM THE BOTTOM OF THE PATTERN.
3. FRAMES SHALL BE MANUFACTURED FROM CAST IRON OR DUCTILE IRON.
4. COVERS SHALL BE MANUFACTURED FROM DUCTILE IRON.

SOURCE:
CITY OF SEATTLE STANDARD PLAN NO. 230 (2011)



TYPICAL 2'–0" DIAMETER FRAME AND COVER (1)

SCALE: N.T.S.



NOTES:
1. MATERIAL – POLYPROPYLENE
2. STEPS AND HANDHOLDS SHALL BE INSTALLED AT 1'–0" SPACING. WHEN THE DISTANCE FROM THE LAST (HIGHEST) STEP OR HANDHOLD TO THE TOP OF THE MANHOLE FRAME EXCEEDS 1'–0" AND ANOTHER STEP OR HANDHOLD CANNOT BE INSTALLED BECAUSE OF THE LOCATION OF THE MANHOLE FRAME, A HANDHOLD SHALL BE INSTALLED BETWEEN THE TOP 2 LAYERS OF BRICK.
3. STEPS AND LADDER SHALL BE FROM THE SAME MANUFACTURER.

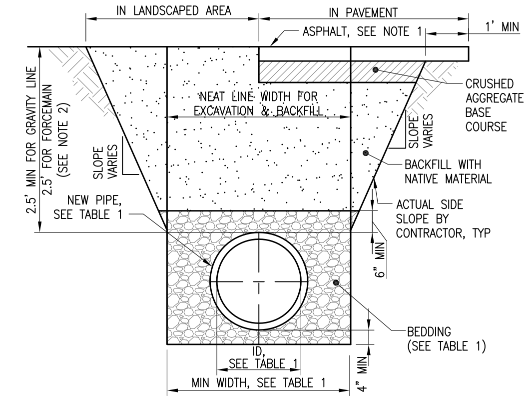
SOURCE:
CITY OF SEATTLE STANDARD PLAN NO. 232 (2011)

TYPICAL MANHOLE LADDER, STEP AND HANDHOLD (2)

SCALE: N.T.S.

TABLE 1

TYPE	ID	WIDTH	BEDDING
HDPE FORCEMAIN	6"	40"	MINERAL AGGREGATE TYPE 22
HDPE FORCEMAIN	7.5"	40"	MINERAL AGGREGATE TYPE 22
DIP FORCEMAIN	12"	40"	MINERAL AGGREGATE TYPE 9
HDPE (OR PVC) GRAVITY LINE	24.5"	55"	MINERAL AGGREGATE TYPE 22

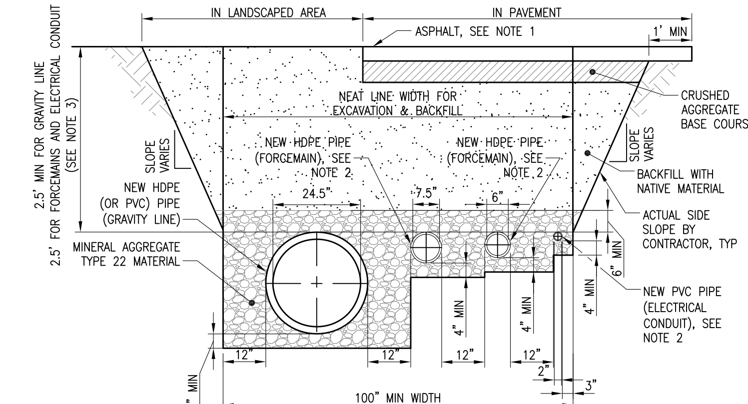


NOTE:
1. RESTORE FINISH GRADE TO EXISTING.
2. IF COVER DEPTH ABOVE FORCEMAIN(S) IS LESS THAN REQUIRED, REPLACE SPECIFIED BACKFILL MATERIAL WITH CONTROLLED DENSITY FILL IN ACCORDANCE WITH COS 2–10.2(3)A2.

SOURCE:
CITY OF SEATTLE STANDARD PLAN NO. 284 (2011)

TYPICAL SECTION – GRAVITY LINE OR FORCEMAIN (3)

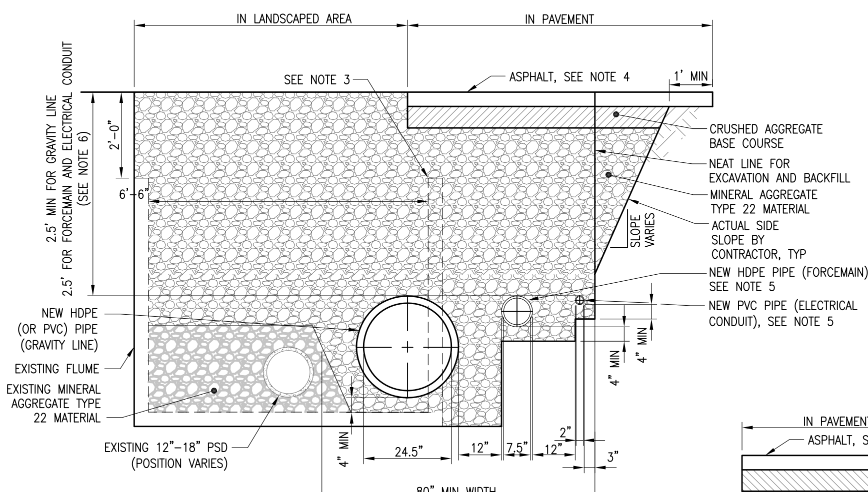
SCALE: N.T.S.



NOTE:
1. RESTORE FINISH GRADE TO EXISTING.
2. SEE PLAN SHEETS C295, C296 AND C301 FOR ALIGNMENT OF FORCEMAINS AND ELECTRICAL CONDUIT.
3. IF COVER DEPTH ABOVE FORCEMAIN(S) IS LESS THAN REQUIRED, REPLACE SPECIFIED BACKFILL MATERIAL WITH CONTROLLED DENSITY FILL IN ACCORDANCE WITH COS 2–10.2(3)A2.

TYPICAL SECTION – GRAVITY LINE, FORCEMAINS AND ELECTRICAL CONDUIT (4)

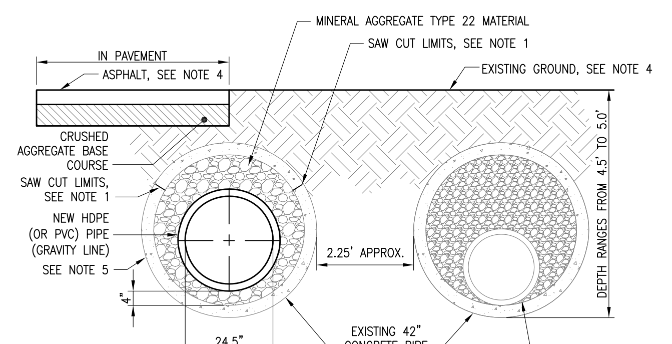
SCALE: N.T.S.



NOTES:
1. CONTRACTOR SHALL PROTECT EXISTING UTILITIES.
2. TYPE 17 OR 22 MATERIAL IN THE EXISTING FLUME SHALL BE EXCAVATED FOR NEW PIPE AND BEDDING MATERIAL.
3. DEMOLISH EXISTING CONCRETE OR WOOD FLUME WALL IF THE WALL INTERFERES WITH NEW HDPE PIPES OR ELECTRICAL CONDUIT.
4. RESTORE FINISH GRADE TO EXISTING.
5. SEE PLAN SHEETS C295, C296, AND C301 FOR ALIGNMENT OF FORCEMAIN AND ELECTRICAL CONDUIT.
6. IF COVER DEPTH ABOVE FORCEMAIN(S) IS LESS THAN REQUIRED, REPLACE MINERAL AGGREGATE TYPE 22 WITH CONTROLLED DENSITY FILL IN ACCORDANCE WITH COS 2–10.2(3)A2.

TYPICAL SECTION – GRAVITY LINE AND FORCEMAIN IN FLUME(S) (5)

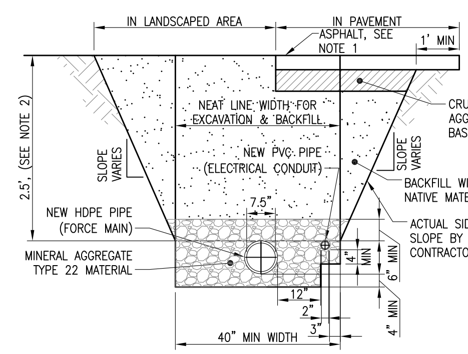
SCALE: N.T.S.



NOTES:
1. CONTRACTOR TO DETERMINE EXACT SAW CUT LIMITS ON EXISTING 42-INCH PIPE. AFTER SAW CUTTING, REMOVE TOP PORTION OF PIPE AND EXCAVATE EXISTING CDF AND THEN PLACE NEW 24-INCH HDPE PIPE AND BEDDING MATERIALS, AS SHOWN.
2. WEIGHT PIPE PRIOR TO PLACING BEDDING MATERIAL TO PREVENT FLOTATION.
3. CONTRACTOR SHALL PROTECT ADJACENT 18" AND 42" PIPES.
4. RESTORE FINISH GRADE TO EXISTING.
5. A FIRE SERVICE LINE COULD POTENTIALLY EXIST ABOVE THE 42" CONCRETE PIPE BASED ON THE OWNER'S BASE MAP. THE FIRE SERVICE LINE WAS NOT FIELD VERIFIED. IF THE FIRE SERVICE LINE EXISTS ABOVE OR NEAR THE 42–INCH LINE, IT SHALL BE PROTECTED OR RELOCATED WITH THE APPROVAL OF THE OWNER.

TYPICAL SECTION – GRAVITY LINE IN EXISTING 42–INCH LINE (6)

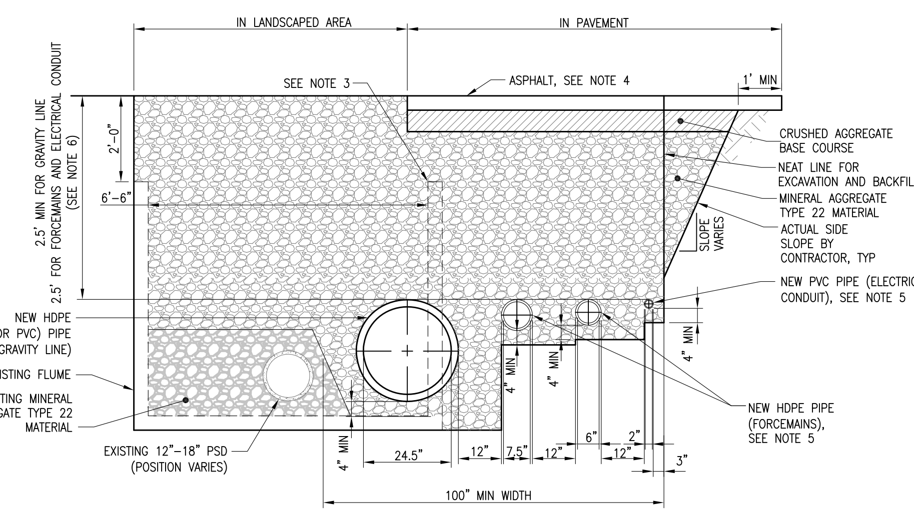
SCALE: N.T.S.



NOTE:
1. RESTORE FINISH GRADE TO EXISTING.
2. IF COVER DEPTH ABOVE FORCEMAIN(S) IS LESS THAN REQUIRED, REPLACE SPECIFIED BACKFILL MATERIAL WITH CONTROLLED DENSITY FILL IN ACCORDANCE WITH COS 2–10.2(3)A2.

TYPICAL SECTION – FORCEMAIN AND ELECTRICAL CONDUIT (7)

SCALE: N.T.S.



NOTES:
1. CONTRACTOR SHALL PROTECT EXISTING UTILITIES.
2. TYPE 17 OR 22 MATERIAL IN THE EXISTING FLUME SHALL BE EXCAVATED FOR NEW PIPE AND BEDDING MATERIAL.
3. DEMOLISH EXISTING CONCRETE OR WOOD FLUME WALL IF THE WALL INTERFERES WITH NEW HDPE PIPES OR ELECTRICAL CONDUIT.
4. RESTORE FINISH GRADE TO EXISTING.
5. SEE PLAN SHEETS C295, C296, AND C301 FOR ALIGNMENT OF FORCEMAINS AND ELECTRICAL CONDUIT.
6. IF COVER DEPTH ABOVE FORCEMAIN(S) IS LESS THAN REQUIRED, REPLACE MINERAL AGGREGATE TYPE 22 WITH CONTROLLED DENSITY FILL IN ACCORDANCE WITH COS 2–10.2(3)A2.

TYPICAL SECTION – GRAVITY LINE, FORCEMAINS AND ELECTRICAL CONDUIT IN FLUME(S) (8)

SCALE: N.T.S.

URS
1501 4TH AVENUE, STE. 1400
SEATTLE, WA 98101-1616
TELEPHONE (206) 438-2700

SYM	REVISION	BY	APPROVED	DATE
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C	PHASE 2 RE–ROUTE STORMWATER LINES – 100% DESIGN	URS	CASTRO	06.24.11

BOEING®

ACCEPTABILITY
THIS DESIGN AND/OR SPECIFICATION IS APPROVED
APPROVED BY | DEPT. | DATE

DRAWN: STICKEL, DATE 06.24.11
CHECKED
ENGINEER: CASTRO, 06.24.11
CHECKED
APPROVED
APPROVED

SUBTITLE: SECTIONS AND DETAILS

TITLE: PHASE 2 RE–ROUTE STORMWATER LINES
NORTH BOEING FIELD

CIVIL MASTER — COL. — NBF

CURRENT REVISION SYMBOL: D
DATE: 06.24.11
SHEET: C502
JOB NO.
COMP NO.
DWG NO. 3.YD–C301

STRUCTURAL GENERAL NOTES

GENERAL:

1. THE STRUCTURAL DRAWINGS REPRESENT THE COMPLETED STRUCTURE AND ARE NOT INTENDED TO INDICATE THE MEANS AND METHOD OF CONSTRUCTION. THE CONTRACTOR SHALL PROVIDE AND BE RESPONSIBLE FOR ALL SHORING, BRACING, SCAFFOLDING, FORM WORK, GUYS, RIGGING AND OTHER TEMPORARY SUPPORTS AS NEEDED TO SAFELY RESIST ALL LOADING IMPOSED UPON THE STRUCTURE BOTH DURING THE REMOVAL OF ANY EXISTING STRUCTURE AND DURING ERECTION AND CONSTRUCTION.
2. AS A MINIMUM, ERECTION AND CONSTRUCTION PROCEDURES SHALL CONFORM TO THE REQUIREMENTS OF APPLICABLE ORDINANCES, REGULATIONS AND THE PROVISION OF CODES CITED BELOW.
3. ALL CONSTRUCTION SHALL BE COORDINATED WITH AND SHALL BE SUBJECT TO THE INSPECTION REQUIREMENTS CITED BELOW.
4. THE CONTRACTOR SHALL COORDINATE ALL DIMENSIONS AND DETAILS INCLUDING WALL, FLOOR, AND ROOF OPENINGS BETWEEN THE STRUCTURAL DRAWINGS AND THAT OF OTHER TRADES PRIOR TO COMMENCING WORK. SHOULD THERE BE ANY CONFLICTS, NOTIFY THE ENGINEER FOR CLARIFICATION.
5. EQUIPMENT OR MATERIAL BEING TRANSPORTED TO LOCATION OR TEMPORARILY STORED SHALL NOT EXCEED THE DESIGN LIVE LOAD FOR THE INTENDED STRUCTURE.
6. ANY CONFLICTS BETWEEN THESE NOTES AND THE DRAWINGS SHALL BE BROUGHT TO THE ATTENTION OF THE ENGINEER FOR CLARIFICATION.

CODES:

1. INTERNATIONAL BUILDING CODE (IBC) 2009.
2. ASCE 7-05 MINIMUM DESIGN LOADS FOR BUILDINGS AND OTHER STRUCTURES.
3. AMERICAN CONCRETE INSTITUTE (ACI) 318-05, 350-04.
4. AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC) SPECIFICATION FOR STRUCTURAL STEEL BUILDINGS ALLOWABLE STRESS DESIGN, 9TH EDITION 1989.
5. AMERICAN WELDING SOCIETY (AWS) D1.1, STRUCTURAL WELDING CODE STEEL.

DESIGN LIVE LOADS:
CHEMICAL STORAGE – 250 PSF
MAINTENANCE AREA – 250 PSF
– 5,000 LB CONCENTRATED LOAD
– 10,000 LB FORKLIFT
ROOF SNOW LOAD – 25 PSF
"FRAC" TANK PADS – AASHTO H20

WIND DESIGN DATA:
BASIC WIND SPEED – 85 MPH, EXPOSURE C

SEISMIC DESIGN DATA:
MAPPED SPECTRAL RESPONSE – Ss = 155 AND S1 = 53
SEISMIC IMPORTANCE FACTOR – Ie = 1.25 TABLE 1604.5 WATER TREATMENT AND WASTE WATER FACILITIES
SEISMIC IMPORTANCE FACTOR – Ie = 1.25 TABLE 1604.5 PRIMARY WATER SUPPLY
SOIL SITE CLASS – SITE CLASS C
SPECTRAL RESPONSE COEFFICIENTS – SDS = 103, SD1 = 53
SEISMIC DESIGN CATEGORY – D
REMAINING SEISMIC VALUES AND RESPONSE FACTOR – STRUCTURE SPECIFIC

ALLOWABLE DESIGN STRESSES:
CONCRETE SLAB ON GRADE – 4,000 PSI

REINFORCEMENT:
WELDED REBAR (ASTM A706) – FY = 60,000 PSI
REINFORCEMENT BARS (ASTM A615) – FY = 60,000 PSI
WELDED WIRE FABRIC (ASTM A185) – FY = 65,000 PSI

STRUCTURAL STEEL:
STEEL W-SHAPES AND CHANNELS (ASTM A992) – FY = 50,000 PSI
STRUCTURAL STEEL (ASTM A36) – FY = 36,000 PSI
HSS TUBING (ASTM A500, GRADE B) – FY = 46,000 PSI
STEEL PIPE (ASTM A53, TYPE E OR S) – FY = 35,000 PSI
STEEL DECK (ASTM A4 46, GRADE C OR ASTM A611, GRADE D) – FY = 40,000 PSI
WELDING ELECTRODE (E-70) – FY = 70,000 PSI

FOUNDATIONS:

1. SUBGRADE PREPARATION INCLUDING DRAINAGE, EXCAVATION, COMPACTION AND FILLING REQUIREMENTS, SHALL CONFORM STRICTLY WITH RECOMMENDATIONS GIVEN IN THE SOILS REPORT OR AS DIRECTED BY GEOTECHNICAL ENGINEER.
2. ALL FOUNDATION EXCAVATIONS INCLUDING ALL FOOTING BEARING SURFACES SHALL BE OBSERVED PRIOR TO PLACEMENT OF REINFORCEMENT AND CONCRETE TO ASSURE SUITABLE BEARING. CONTRACTOR SHALL COORDINATE TIMELY OBSERVATIONS AND APPROVALS.
3. BEAR ALL FOOTINGS ON INORGANIC, UNDISTURBED, DENSE SANDY GRAVEL SOIL OR IN STRUCTURAL FILL AT DEPTHS INDICATED ON DRAWINGS.
4. NO FOOTING SHALL BE PLACED HIGHER THAN 2.0 HORIZONTAL TO 1.0 VERTICAL FROM ANY ADJACENT EXCAVATION.
5. MINIMUM FROST DEPTH BELOW GRADE 18"
6. MINIMUM ALLOWABLE BEARING PRESSURE REQUIRED IS 3000 PSF.
7. GEOTECHNICAL REPORT REFERENCE:
BOEING 3-380 PROPOSED AIRCRAFT PAINTING FACILITY (DAMES & MOORE, 1990) AND BUILDING 3-369 ADDITION (DAMES & MOORE, 1990).

CONCRETE

1. DESIGN, MATERIAL AND WORKMANSHIP SHALL BE IN ACCORDANCE WITH THE FOLLOWING STANDARDS UNLESS OTHERWISE MODIFIED ON THE DRAWINGS.
   - IBC 2009
   - ACI 318-08 BUILDING CODE REQUIREMENTS FOR REINFORCED CONCRETE
   - ACI SP-66 DETAILING MANUAL
   - ACI 301-08 SPECIFICATIONS FOR STRUCTURAL CONCRETE
   - ACI 350-1, 350 R-08 CODE REQUIREMENTS FOR ENVIRONMENTAL ENGINEERING CONCRETE STRUCTURES
   - CRSI RECOMMENDED PRACTICE FOR PLACING REINFORCING BARS
2. PRIOR TO SHIPPING OF REINFORCING STEEL TO THE FIELD, SHOP DRAWINGS SHALL BE SUPPLIED TO THE ENGINEER FOR REVIEW AND APPROVAL.
3. ALL CONCRETE SHALL CONTAIN A WATER-REDUCING ADMIXTURE AND/OR A HIGH-RANGE WATER-REDUCING ADMIXTURE, REDUCING THE WATER BY AT LEAST 10 PERCENT FROM THE SAME MIX WITHOUT THE ADMIXTURE.
4. NO WATER FROM THE TRUCK SYSTEM OR ELSEWHERE SHALL BE ADDED AFTER THE INITIAL INTRODUCTION OF MIXING WATER FOR THE BATCH.
5. NOMINAL MAXIMUM SIZE OF AGGREGATE SHALL BE 3/4 INCH. NOMINAL MAXIMUM SIZE OF AGGREGATE IN CONCRETE ON STEEL DECK SHALL BE 3/8 INCH. MAXIMUM SIZE AGGREGATE IN SPREAD FOOTING SHALL BE 1 INCH. AGGREGATE SHALL CONFORM TO ASTM C33, LATEST EDITION.
6. PROVIDE A MINIMUM COVER AS SPECIFIED IN ACI 318, BUT NOT LESS THAN THE FOLLOWING:
   - CONCRETE PLACED DIRECTLY AGAINST GROUND – 3"
   - CONCRETE EXPOSED TO WEATHER (#6 OR LARGER) – 2"; (#5 OR SMALLER) – 1 1/2"
   - CONCRETE NOT EXPOSED TO WEATHER, OR GROUND SLABS, WALLS AND JOISTS (#11 OR SMALLER) – 3/4"; BEAMS AND COLUMNS – 1 1/2"
7. FOR CONCRETE MIX INFORMATION, SEE ACI.
8. REINFORCEMENT INCLUDING WELDED WIRE FABRIC SHALL BE POSITIVELY SUPPORTED IN THE POSITION AS SHOWN ON THE DRAWINGS AND SHALL BE MAINTAINED IN THIS POSITION DURING THE PLACING OF CONCRETE.
9. ALL EXPOSED EDGES OF CONCRETE SHALL HAVE A 3/4 INCH 45 DEGREE CHAMFER.
10. REFER TO MECHANICAL, PIPING AND ELECTRICAL DRAWINGS FOR EMBEDDED ITEMS.
11. FLOOR FINISHES SHALL BE AS SHOWN ON THE DRAWINGS.
12. ALL WELDED WIRE FABRIC SHALL BE LAPPED AT LEAST 12 INCHES. ALL REINFORCEMENT BAR LAPS SHALL CONFORM TO IBC CLASS "B" LAP REQUIREMENTS. STAGGER SPLICES WHEREVER POSSIBLE.
13. WELDING OF REINFORCING STEEL IS PROHIBITED.
14. ALL REINFORCING BAR BENDS SHALL BE MADE COLD BEND. RADII TO BE PER ACI.
15. NO ALUMINUM CONDUITS OR PIPES SHALL BE EMBEDDED IN CONCRETE. THE USE OF ALUMINUM PIPES OR CHUTES TO TRANSPORT CONCRETE SHALL NOT BE PERMITTED.
16. EPOXY BONDING AGENT: EPOXY-BASED BONDING AGENT, CONFORMING TO ASTM C-881, TYPE 2, GRADE 2. "EPOBOND" BY L&M CONSTRUCTION CHEMICALS, INC., OR ENGINEER APPROVED EQUAL, APPLIED IN ACCORDANCE WITH MANUFACTURER'S PRINTED INSTRUCTIONS.
17. CONSTRUCTION JOINTS BELOW GRADE SHALL BE CONSTRUCTED WITH KEY AND WATERSTOP PER TYPICAL DETAIL.
18. TIE ALL EMBEDDED ANCHOR BOLTS IN PLACE PRIOR TO CONCRETE POUR.

REINFORCING STEEL

1. REINFORCING BARS SHALL CONFORM TO ASTM A615 GRADE 60. BARS TO BE WELDED SHALL BE ASTM A706.
2. WELDED WIRE FABRIC SHALL CONFORM TO ASTM A-185.
3. DETAIL, FABRICATE, LABEL, SUPPORT AND SPACE ALL CONCRETE REINFORCEMENT IN ACCORDANCE WITH ACI 315, ACI 318 AND THE INTERNATIONAL BUILDING CODE.
4. ALL REINFORCING BAR BENDS SHALL BE MADE COLD.
5. REINFORCING SPLICES SHALL BE AS SHOWN ON THE DRAWINGS OR PER ACI REQUIREMENTS.
6. FOR WELDING OF REINFORCING, SEE SPECIFICATIONS.
7. WELDING OF A706 BARS SHALL BE MADE WITH E80XX ELECTRODES BY QUALIFIED WELDERS.

EQUIPMENT SLABS:

1. SLAB FOUNDATIONS SHALL BE PROVIDED FOR OUTDOOR EQUIPMENT NOT CONNECTED TO OTHER STRUCTURES (EG., EMERGENCY GENERATORS, DIESEL STORAGE TANKS, UTILITY TRANSFORMERS, LOAD BANKS, ETC.).
2. SLABS SHALL BE 12" THICK, WITH 4" EXPOSED ABOVE GRADE.
3. SLABS SHALL BE REINFORCED TOP AND BOTTOM WITH #6 @ 12" SPACING EACH WAY WITH 2" CLEAR FOR TOP LAYER AND 3" CLEAR FOR BOTTOM LAYER.
4. SLABS SHALL EXTEND A MINIMUM OF 12" BEYOND THE EQUIPMENT FOOTPRINT IN ALL DIRECTIONS.
5. EQUIPMENT ANCHORAGE TO THE SLAB SHALL BE AS RECOMMENDED BY THE EQUIPMENT MANUFACTURER.

MECHANICAL AND ADHESIVE ANCHORS:

1. WHERE INDICATED ON DRAWINGS, MECHANICAL ANCHORS SHALL BE HILTI KWIK BOLT TZ INSTALLED IN COMPLIANCE WITH ICC ESR 1917.
2. WHERE INDICATED ON DRAWINGS, ADHESIVE ANCHORS SHALL BE HILTI HIT RE500SD INSTALLED IN COMPLIANCE WITH ICC ESR 2322.

STRUCTURAL OBSERVATION:
FOUNDATION REINFORCEMENT PRIOR TO CONCRETE POUR.
CONCRETE WALL REINFORCEMENT PRIOR TO CONCRETE POUR.

TESTING:
CONCRETE

SPECIAL INSPECTION:
PLACEMENT OF CONCRETE AND REINFORCEMENT

URS
1501 4TH AVENUE, STE. 1400
SEATTLE, WA 98101-1616
TELEPHONE (206) 438-2700

SYM	REVISION	BY	APPROVED	DATE	SYM	REVISION	BY	APPROVED	DATE
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C	PHASE 2 RE-ROUTE STORMWATER LINES – 100% DESIGN	URS	GILLESPIE	06.24.11					

ACCEPTABILITY
THIS DESIGN AND/OR SPECIFICATION IS APPROVED

APPROVED BY	DEPT.	DATE

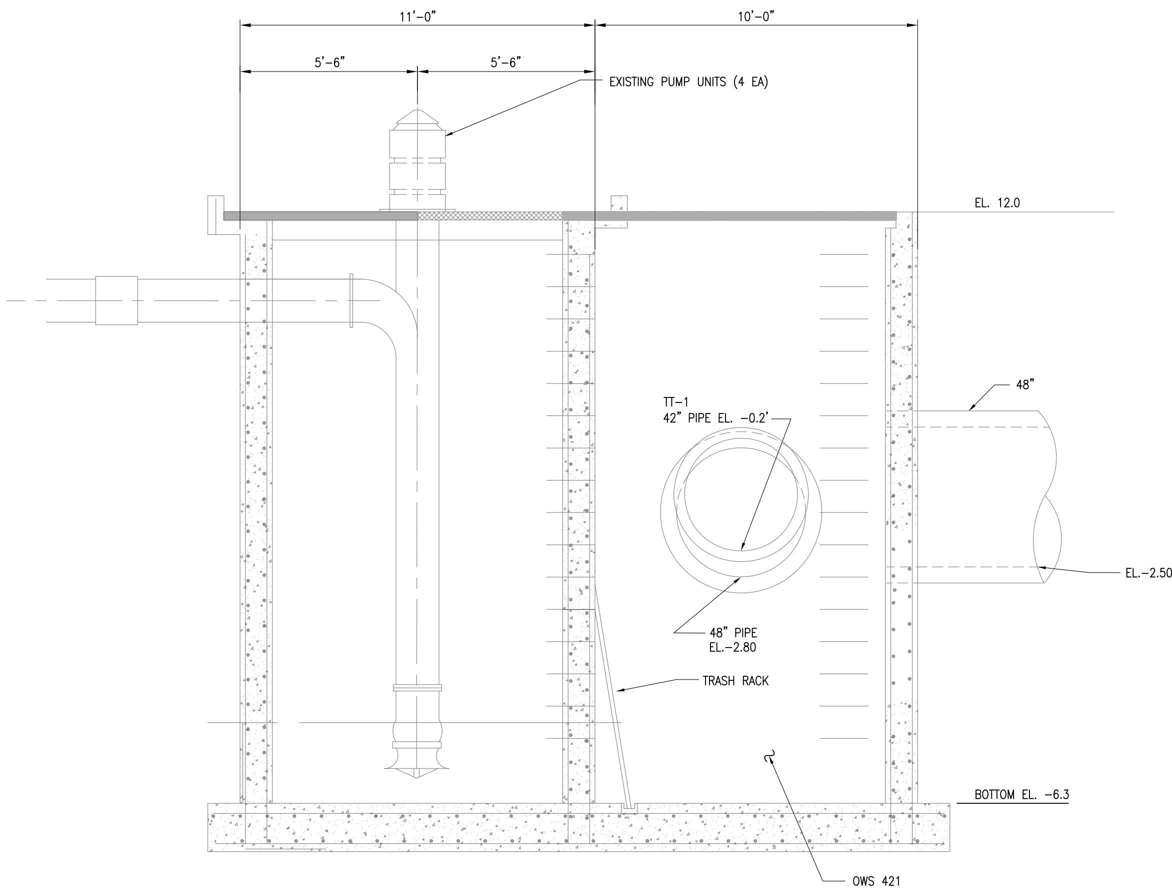
DRAWN	MUENCH	DATE 06.24.11
CHECKED		
ENGINEER	CASTRO	06.24.11
CHECKED		
APPROVED		
APPROVED		

SUBTITLE: STRUCTURAL GENERAL NOTES

TITLE: PHASE 2 RE-ROUTE STORMWATER LINES
NORTH BOEING FIELD

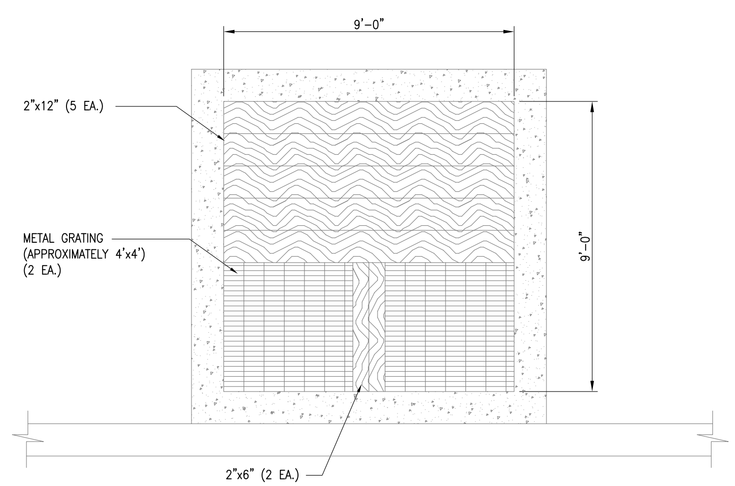
MECHANICAL MASTER COL. NBF

CURRENT REVISION	SYMBOL D	DATE 06.24.11
SHEET S2		
JOB NO. 972108-00		COMP NO.
DWG NO. 3.YD-S2		



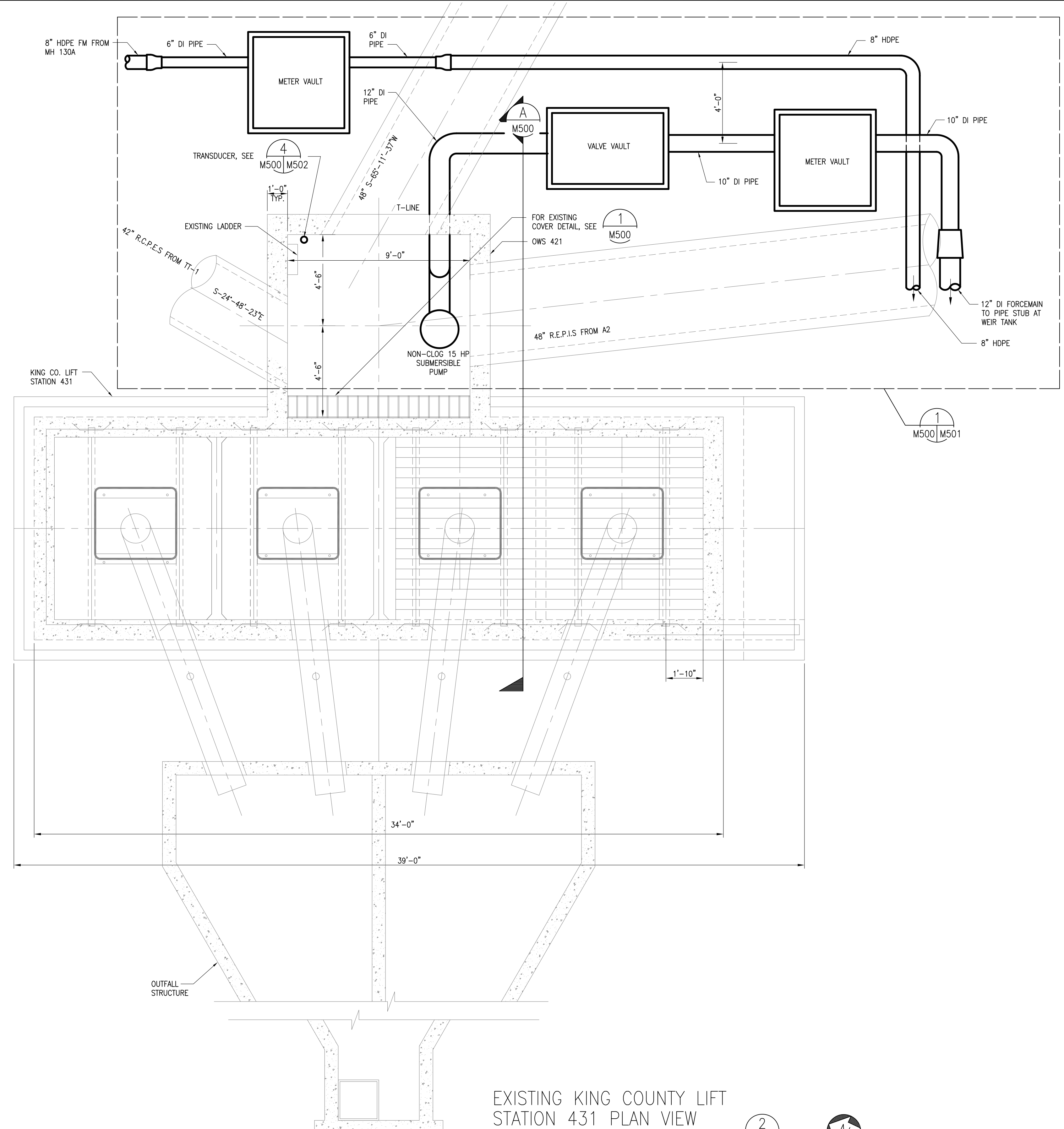
EXISTING KING COUNTY LIFT STATION 431 SECTION (A / M500)

SCALE: 3/8"=1'-0"



EXISTING COVER FOR OWS 421 (1 / M500)

SCALE: 3/8"=1'-0"



EXISTING KING COUNTY LIFT STATION 431 PLAN VIEW (2 / C296 M500)

SCALE: 3/8"=1'-0"

URS
1501 4TH AVENUE, STE. 1400
SEATTLE, WA 98101-1616
TELEPHONE (206) 438-2700

SYM	REVISION	BY	APPROVED	DATE	SYM	REVISION	BY	APPROVED	DATE
A	PHASE 2 RE-ROUTE STORMWATER LINES – 60% DESIGN	URS	GILLESPIE	04.29.11					
B	PHASE 2 RE-ROUTE STORMWATER LINES – 90% DESIGN	URS	GILLESPIE	05.27.11					
C	PHASE 2 RE-ROUTE STORMWATER LINES – 100% DESIGN	URS	GILLESPIE	06.24.11					

BOEING

ACCEPTABILITY
THIS DESIGN AND/OR SPECIFICATION IS APPROVED

APPROVED BY	DEPT.	DATE

DRAWN	JILES	DATE 06.24.11
CHECKED		
ENGINEER	GILLESPIE	06.24.11
CHECKED		
APPROVED		
APPROVED		

SUBTITLE: SECTIONS AND DETAILS

TITLE: PHASE 2 RE-ROUTE STORMWATER LINES
NORTH BOEING FIELD

MECHANICAL MASTER COL. NBF

CURRENT REVISION SYMBOL: D DATE: 06.24.11

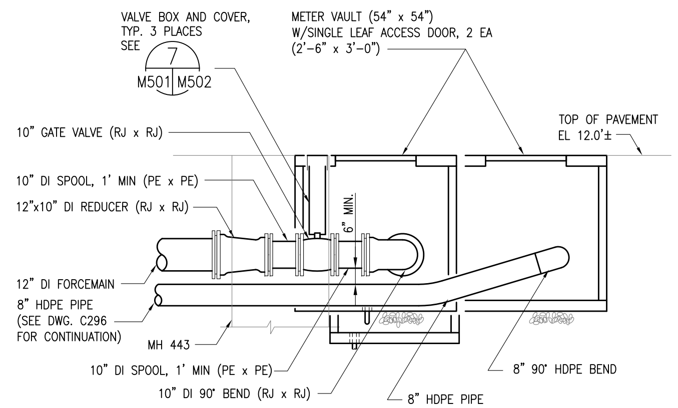
SHEET: M500

JOB NO. 972108-00 COMP NO.

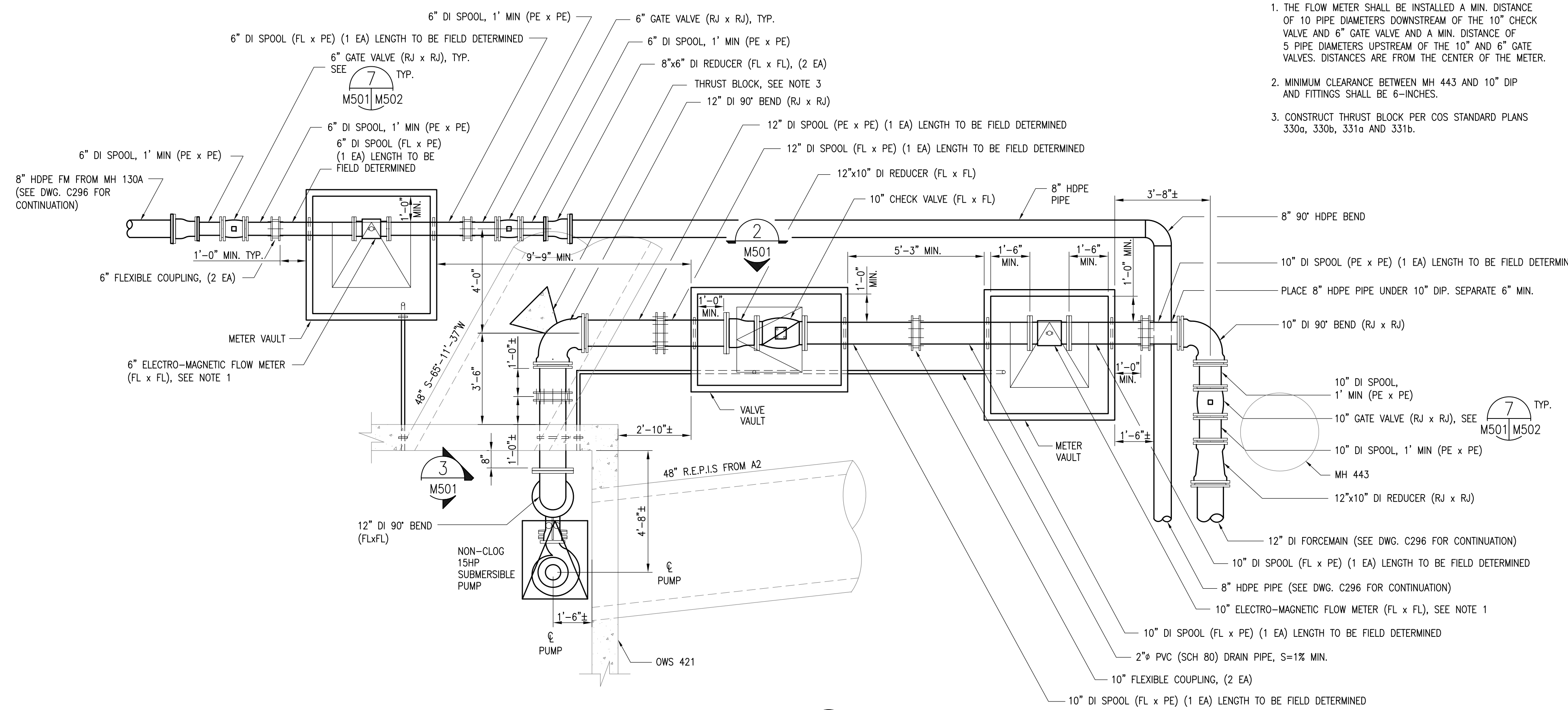
DWG NO. 3.YD-M500

Mod: 06/17/2011, 13:36 | Plotted: 06/24/2011, 10:45 | larry_jiles
Q:\Boeing\NBF\PEL Remediation\Phase 2 Re-Route Storm Lines\R03\Mech\3-YD-M500 - Pump House Sections and Details.dwg

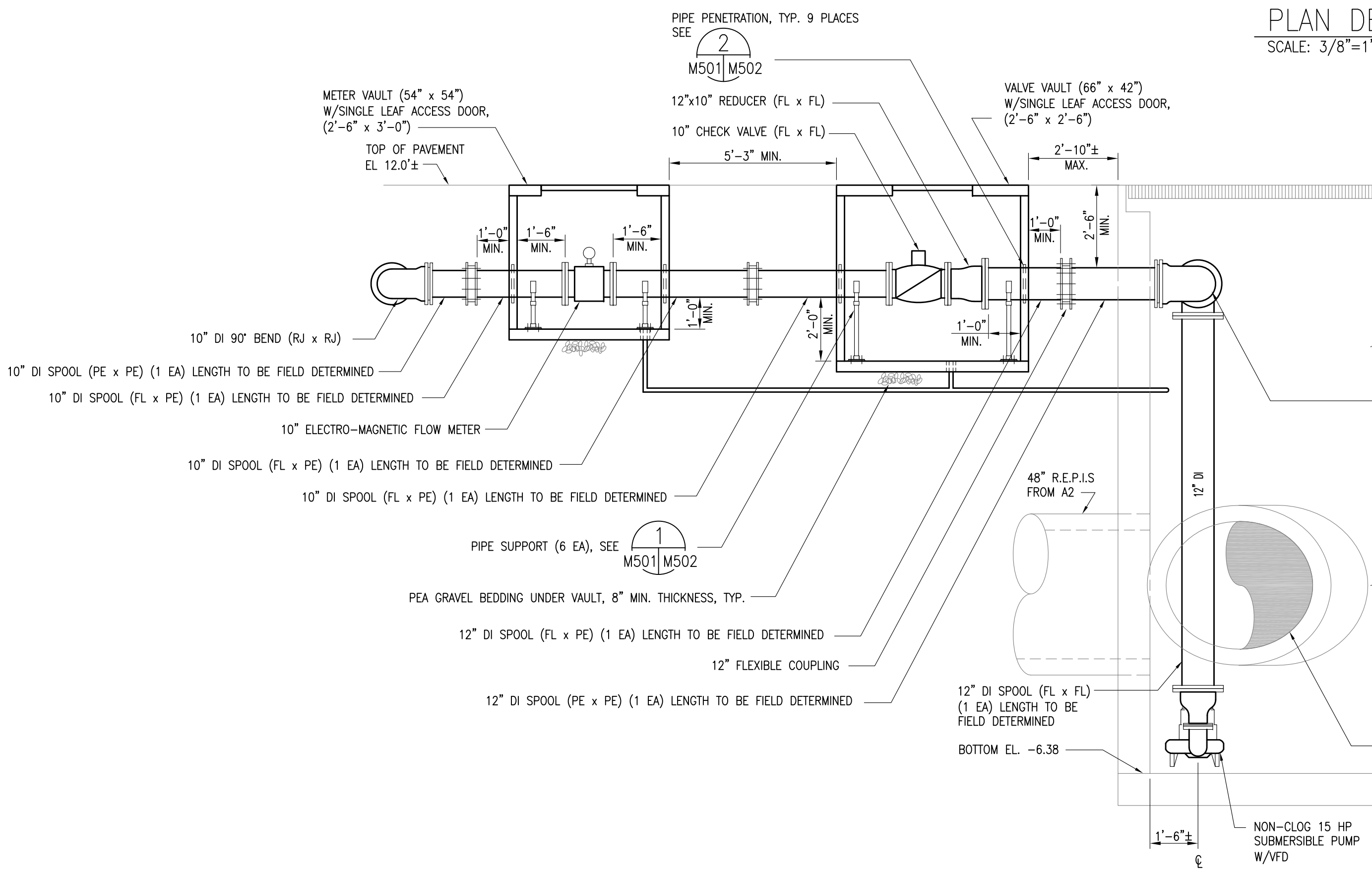
1. THE FLOW METER SHALL BE INSTALLED A MIN. DISTANCE OF 10 PIPE DIAMETERS DOWNSTREAM OF THE 10" CHECK VALVE AND 6" GATE VALVE AND A MIN. DISTANCE OF 5 PIPE DIAMETERS UPSTREAM OF THE 10" AND 6" GATE VALVES. DISTANCES ARE FROM THE CENTER OF THE METER.
2. MINIMUM CLEARANCE BETWEEN MH 443 AND 10" DIP AND FITTINGS SHALL BE 6-INCHES.
3. CONSTRUCT THRUST BLOCK PER COS STANDARD PLANS 330a, 330b, 331a AND 331b.



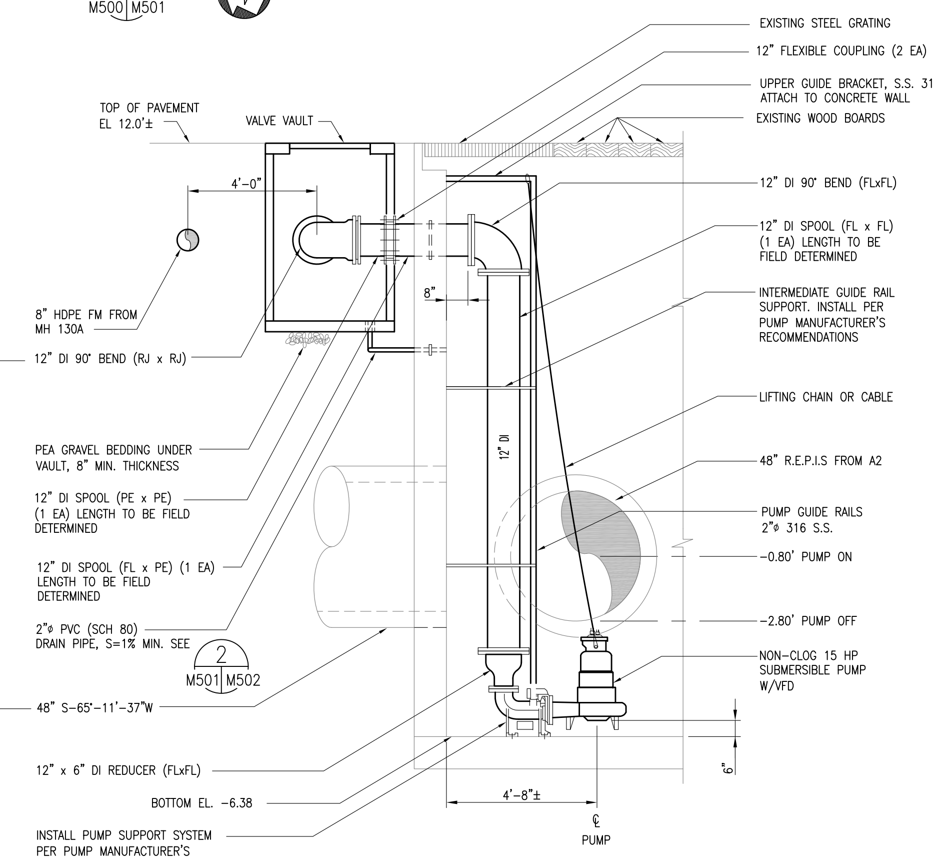
ELEVATION 4
SCALE: 3/8"=1'-0" M501



PLAN DETAIL 1
SCALE: 3/8"=1'-0" M500 M501



ELEVATION 2
SCALE: 3/8"=1'-0" M501



ELEVATION 3
SCALE: 3/8"=1'-0" M501

EXISTING KING CO. PUMP LEVELS

PUMP 4 ON	1.72'
PUMP 4 OFF	-1.03'
PUMP 3 ON	0.72'
PUMP 3 OFF	-1.53'
PUMP 2 ON	-0.03'
PUMP 2 OFF	-2.03'
PUMP 1 ON	-0.53'
PUMP 1 OFF	-2.53'

NOTES:

1. USE S.S. 316 BOLTS AND NUTS, TYP. ALL PLACES.
2. NEW OWS 421 PUMP SHALL OPERATE IN CONJUCTION WITH EXISTING MH 130A PUMP. TOTAL MAXIMUM PUMPING FLOW RATE FROM BOTH PUMPS SHALL BE 1,500 GPM, WHICH CORRESPONDS WITH THE MAXIMUM TREATMENT RATE. MAXIMUM PUMPING FLOW RATE FROM MH 130A PUMP IS APPROXIMATELY 750 GPM. CURRENTLY FLOW IS REDUCED TO APPROXIMATELY 500 GPM BY A WEIR PLATE. THE WEIR PLATE WILL NOT BE USED UNDER THE NEW PIPING SCHEME TO THE LTST FACILITY. THEREFORE, A THROTTLING VALVE AND VAULT SHALL BE INSTALLED NEAR MH 130A TO CONTROL THE FLOW FROM MH 130A TO 530 GPM. SEE DWG. M502. NEW OWS 421 PUMP FLOW RANGE WILL VARY FROM 970 GPM TO 1,475 GPM, DEPENDING UPON THE FLOW RATE FROM MH 130A. FLOW METERS WILL BE USED TO CONTROL THE PUMPING RATE OF THE OWS 421 PUMP.
3. SEE SHEETS E116 AND E500 FOR ELECTRICAL WORK.

Q:\Boeing\NBF\PEL Remediation\Phase 2 Re-Route Storm Lines\R03\Mech\3-YD-M501 - Sump Pump Mechanical Plan, Elevations & Details.dwg   Mod: 06/24/2011, 10:07 | Plotted: 06/24/2011, 10:45 | larry_jiles

URS 1501 4TH AVENUE, STE. 1400 SEATTLE, WA 98101-1616 TELEPHONE (206) 438-2700

SYM	REVISION	BY	APPROVED	DATE
A	PHASE 2 RE-ROUTE STORMWATER LINES – 60% DESIGN	URS	GILLESPIE	04.29.11
B	PHASE 2 RE-ROUTE STORMWATER LINES – 90% DESIGN	URS	GILLESPIE	05.27.11
C	PHASE 2 RE-ROUTE STORMWATER LINES – 100% DESIGN	URS	GILLESPIE	06.24.11

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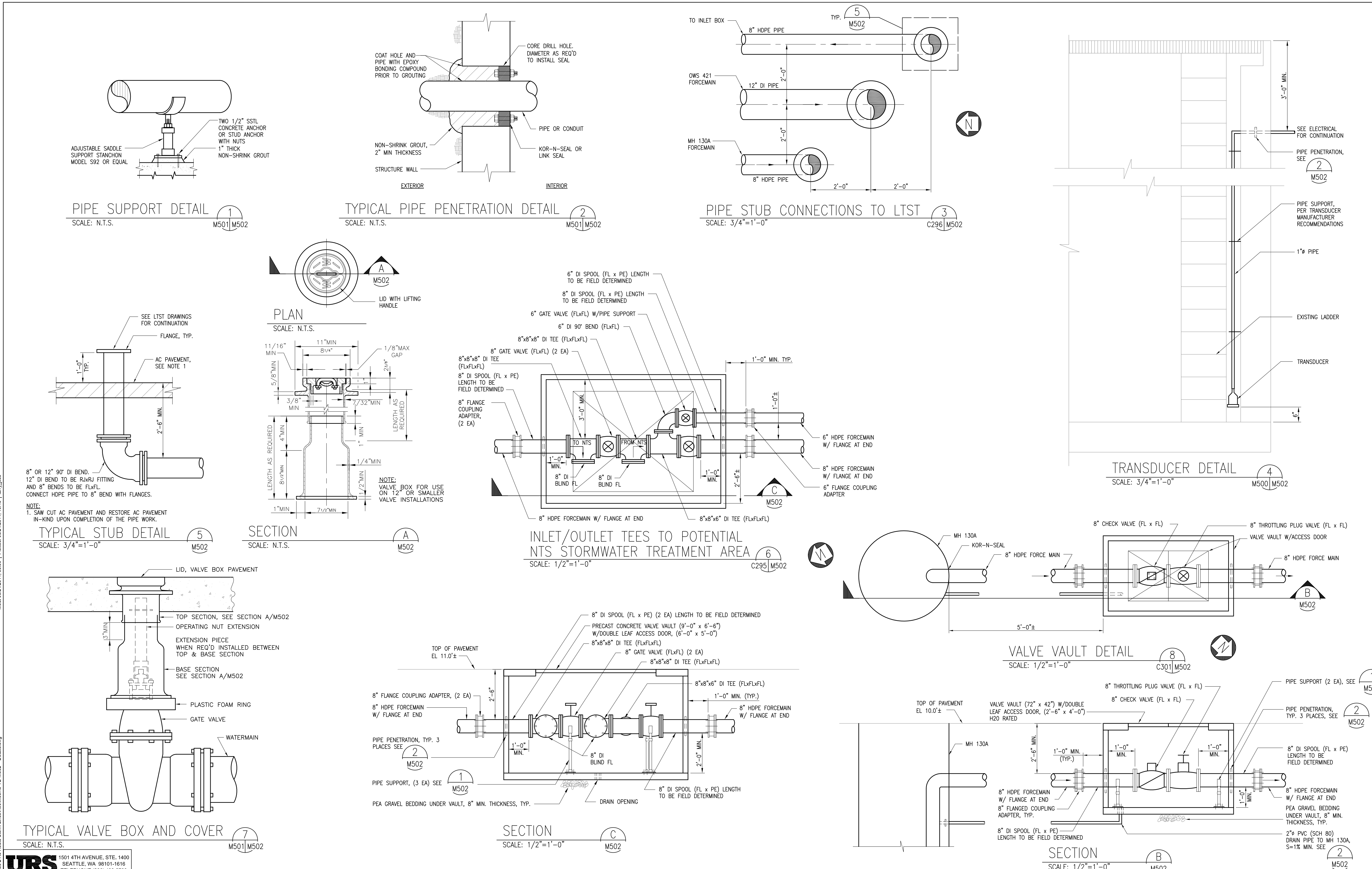
ACCEPTABILITY
THIS DESIGN AND/OR SPECIFICATION IS APPROVED
APPROVED BY | DEPT. | DATE

DRAWN	JILES	06.24.11
CHECKED		
ENGINEER	GILLESPIE	06.24.11
CHECKED		
APPROVED		
APPROVED		

SUBTITLE: PLAN, ELEVATIONS AND DETAILS
TITLE: PHASE 2 RE-ROUTE STORMWATER LINES
NORTH BOEING FIELD
MECHANICAL MASTER   COL.   NBF

CURRENT REVISION SYMBOL: D   DATE: 06.24.11
SHEET: M501
JOB NO. 972108-00   COMP NO.
DWG NO. 3.YD-M501



Mod: 06/24/2011, 08:56 | Plotted: 06/24/2011, 10:45 | larry_liles

Q:\Boeing\NBF\PEL Remediation\Phase 2 Re-Route Storm Lines\R03\Mech\3-YD-M502 - Details.dwg

URS
1501 4TH AVENUE, STE. 1400
SEATTLE, WA 98101-1616
TELEPHONE (206) 438-2700

SYM	REVISION	BY	APPROVED	DATE	SYM	REVISION	BY	APPROVED	DATE
A	PHASE 2 RE-ROUTE STORMWATER LINES – 60% DESIGN	URS	GILLESPIE	04.29.11					
B	PHASE 2 RE-ROUTE STORMWATER LINES – 90% DESIGN	URS	GILLESPIE	05.27.11					
C	PHASE 2 RE-ROUTE STORMWATER LINES – 100% DESIGN	URS	GILLESPIE	06.24.11					

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APPROVED BY	DEPT.	DATE

		DATE
DRAWN	JILES	06.24.11
CHECKED		
ENGINEER	GILLESPIE	06.24.11
CHECKED		
APPROVED		
APPROVED		

SUBTITLE
SECTIONS AND DETAILS

TITLE
PHASE 2 RE-ROUTE STORMWATER LINES
NORTH BOEING FIELD

MECHANICAL MASTER COL. NBF

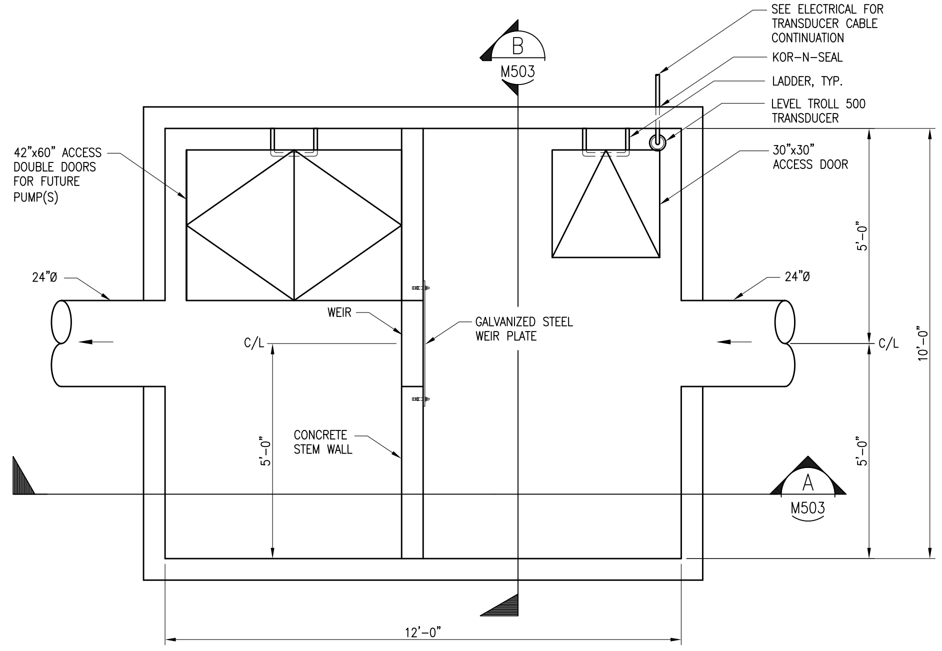
CURRENT REVISION	SYMBOL	DATE
	D	06.24.11

SHEET M502

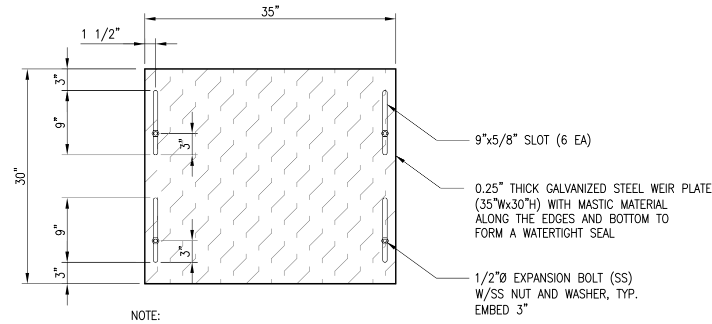
JOB NO. 972108-00

COMP NO.

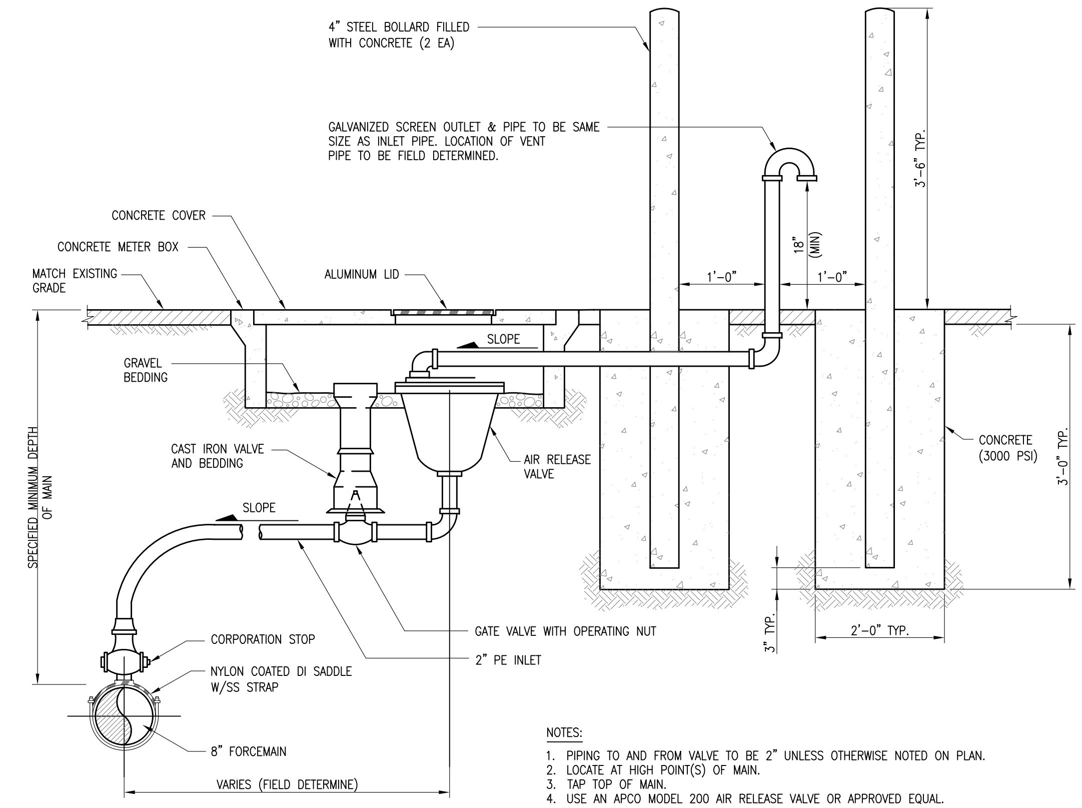
DWG NO. 3.YD-M502



WETWELL PLAN
SCALE: 1/2"=1'-0"
1 C296 M503

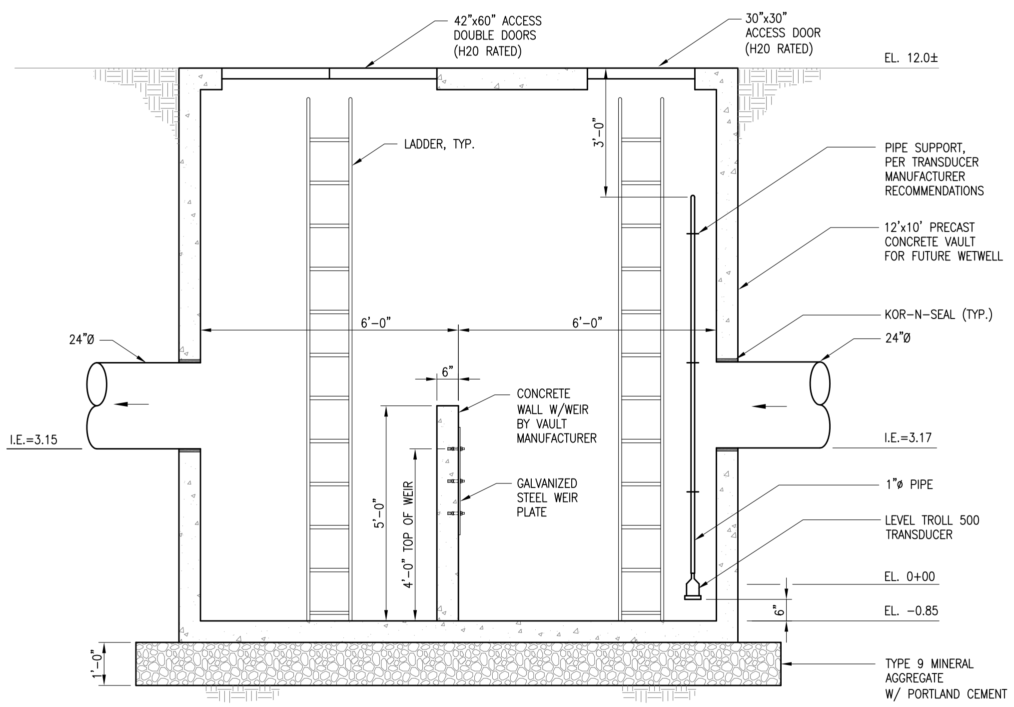


ADJUSTABLE WEIR PLATE DETAIL
SCALE: 1"=1'-0"
2 M503

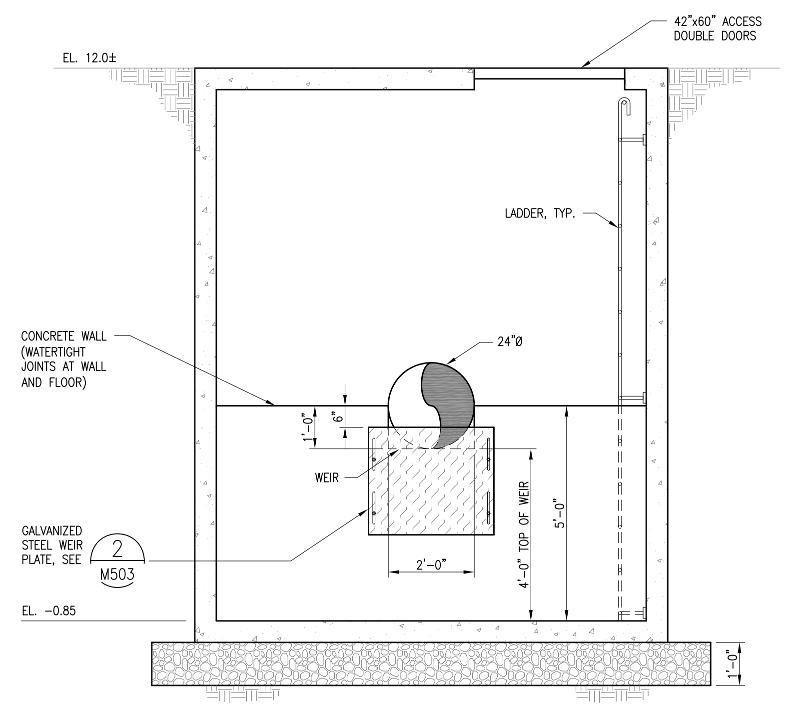


NOTES:
1. PIPING TO AND FROM VALVE TO BE 2" UNLESS OTHERWISE NOTED ON PLAN.
2. LOCATE AT HIGH POINT(S) OF MAIN.
3. TAP TOP OF MAIN.
4. USE AN APCO MODEL 200 AIR RELEASE VALVE OR APPROVED EQUAL.

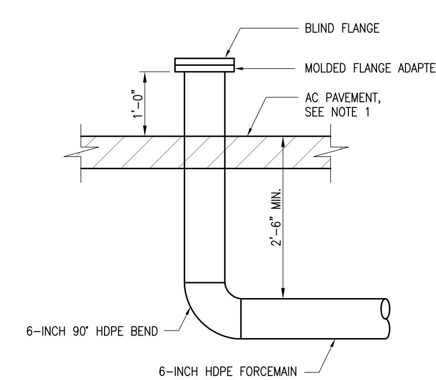
AIR RELEASE VALVE ASSEMBLY FOR 8-INCH FORCEMAIN
SCALE: N.T.S.
3 M503



SECTION
SCALE: 1/2"=1'-0"
A M503



SECTION
SCALE: 1/2"=1'-0"
B M503



NOTE:
1. SAW CUT AC PAVEMENT AND RESTORE AC PAVEMENT IN-KIND UPON COMPLETION OF THE PIPE WORK.

6-INCH FORCEMAIN STUB DETAIL
SCALE: 3/4"=1'-0"
4 C296 M503

Mod: 06/22/2011, 14:40 | Plotted: 06/24/2011, 10:45 | larry_jiles

Q:\Boeing\NBF\PEL Remediation\Phase 2 Re-Route Storm Lines\R03\Mech\3.YD-M503- Details.dwg

URS 1501 4TH AVENUE, STE. 1400 SEATTLE, WA 98101-1616 TELEPHONE (206) 438-2700

SYM	REVISION	BY	APPROVED	DATE	SYM	REVISION	BY	APPROVED	DATE
A	PHASE 2 RE-ROUTE STORMWATER LINES – 60% DESIGN	URS	GILLESPIE	04.29.11					
B	PHASE 2 RE-ROUTE STORMWATER LINES – 90% DESIGN	URS	GILLESPIE	05.27.11					
C	PHASE 2 RE-ROUTE STORMWATER LINES – 100% DESIGN	URS	GILLESPIE	06.24.11					

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ACCEPTABILITY
THIS DESIGN AND/OR SPECIFICATION IS APPROVED

APPROVED BY	DEPT.	DATE

DRAWN	JILES	DATE 06.24.11
CHECKED		
ENGINEER	GILLESPIE	06.24.11
CHECKED		
APPROVED		
APPROVED		

SUBTITLE: SECTIONS AND DETAILS

TITLE: PHASE 2 RE-ROUTE STORMWATER LINES
NORTH BOEING FIELD

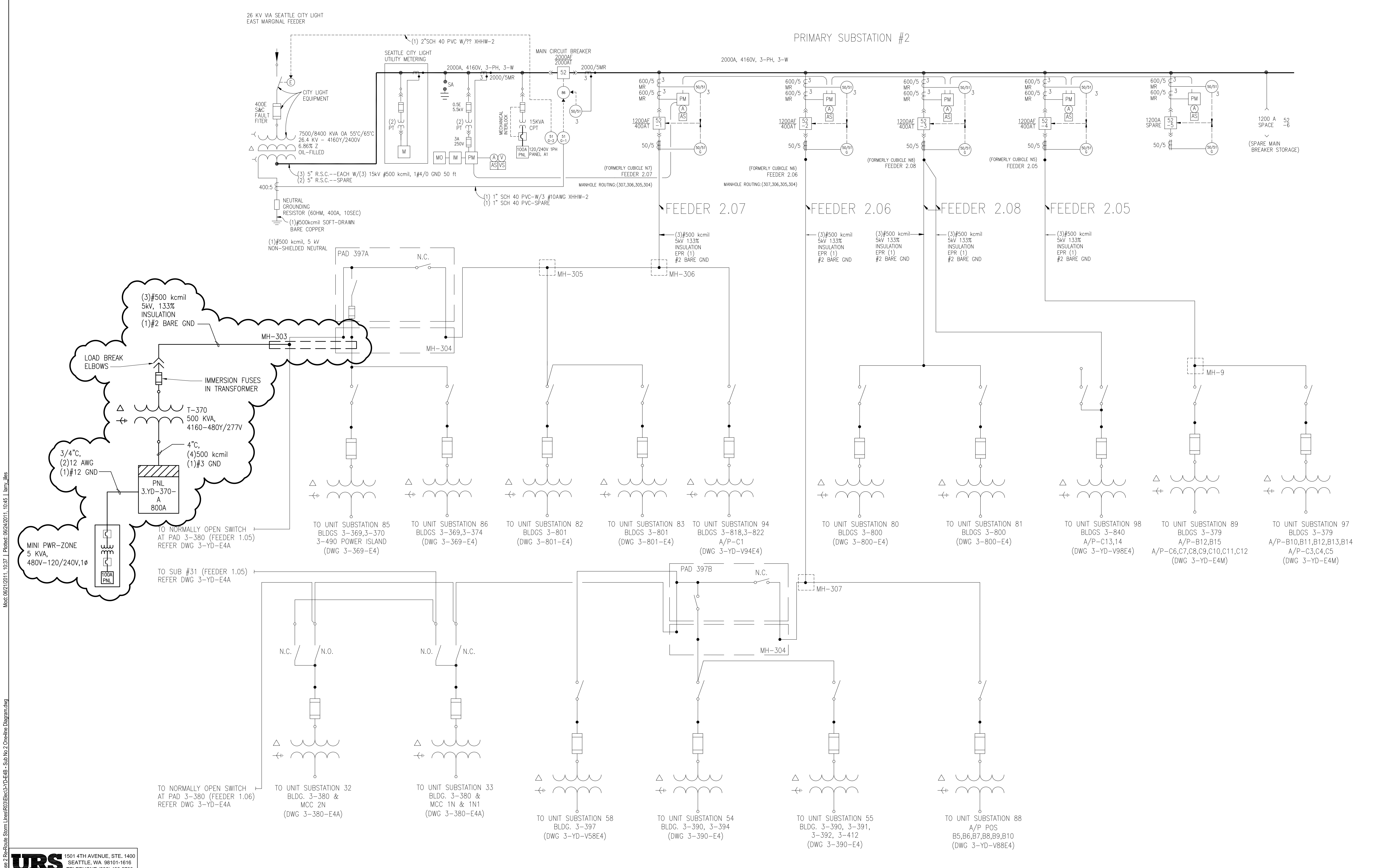
MECHANICAL MASTER COL. NBF

CURRENT REVISION SYMBOL: D DATE: 06.24.11

SHEET: M503

JOB NO. 972108-00 COMP NO.

DWG NO. 3.YD-M503



URS
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SEATTLE, WA 98101-1616
TELEPHONE (206) 438-2700

SYM	REVISION	BY	APPROVED	DATE	SYM	REVISION	BY	APPROVED	DATE
A	PHASE 2 RE-ROUTE STORMWATER LINES – 60% DESIGN	URS	GIBSON	04.29.11					
B	PHASE 2 RE-ROUTE STORMWATER LINES – 90% DESIGN	URS	GIBSON	05.27.11					
C	PHASE 2 RE-ROUTE STORMWATER LINES – 100% DESIGN	URS	GIBSON	06.24.11					

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ACCEPTABILITY
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APPROVED BY	DEPT.	DATE

		DATE
DRAWN	OLSZEWSKI	06.24.11
CHECKED		
ENGINEER	GIBSON	06.24.11
CHECKED		
APPROVED		
APPROVED		

SUBTITLE: SUB NO. 2 - LINEUP "B" ONE-LINE DIAGRAM

TITLE: PHASE 2 RE-ROUTE STORMWATER LINES
NORTH BOEING FIELD

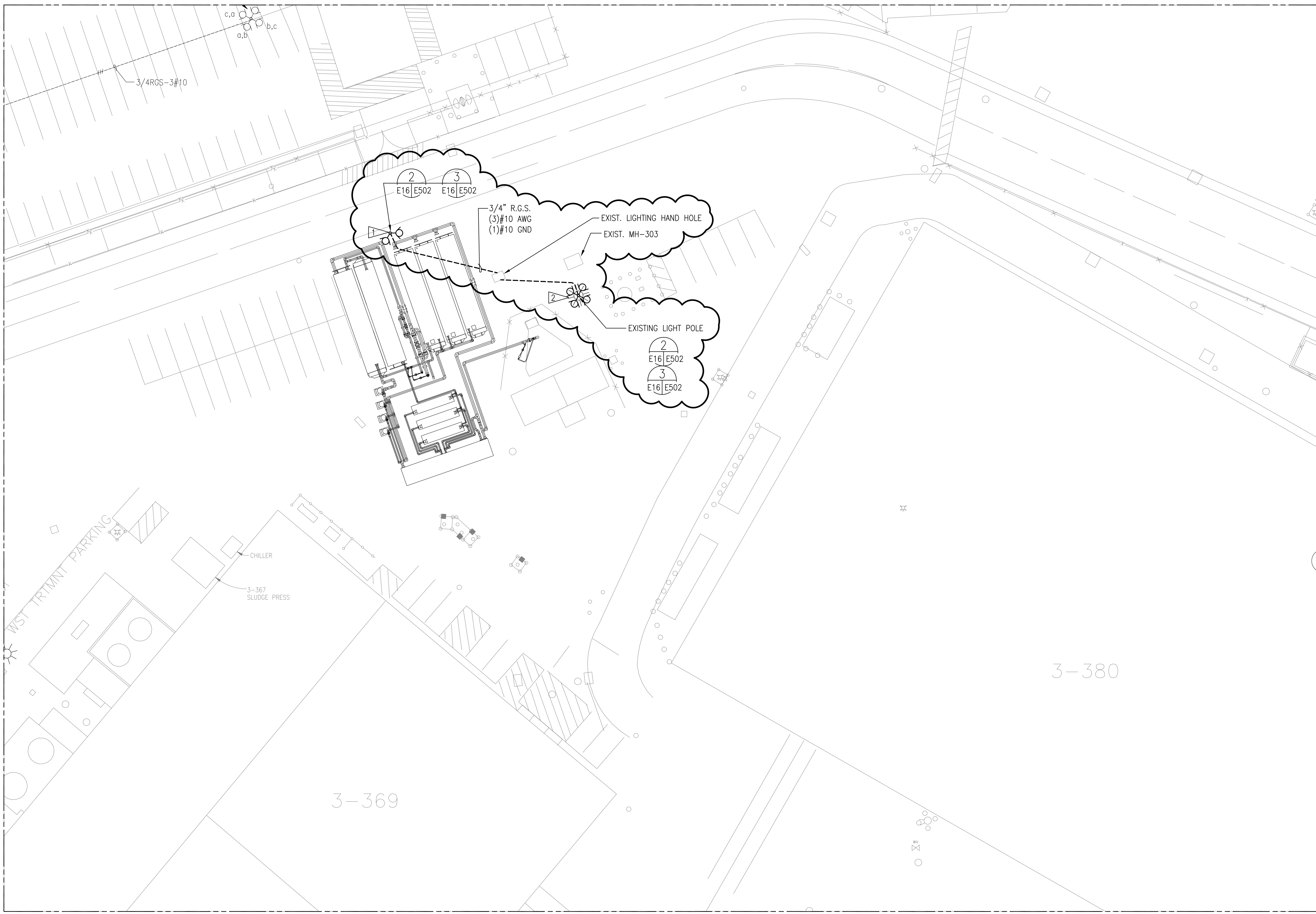
ELECTRICAL MASTER COL. NBF

CURRENT REVISION SYMBOL: D DATE: 06.24.11
SHEET: E4B
JOB NO.: 972108-00 COMP NO.
DWG NO.: 3.YD-E4B

ALPA_OLSZEWSKI: 05/24/11 13:45

Mod: 06/21/2011, 10:37 | Plotted: 06/24/2011, 10:45 | larry_liles

O:\Boeing\NBF\PEL Remediation\Phase 2 Re-Route Storm Lines\R03\Elec\3-YD-E4B - Sub No 2 One-line Diagram.dwg



LEGEND:

POLES: LYTE POLE P/N 301-9011-39 DB W/2" TENDON AND BASE COVER (AVAILABLE THROUGH WIDELITE).

2 FIXTURES & BRACKET:
EFIZ-400-W-480-DB-SK-40-EFX-DB-PTA-2090

4 FIXTURES & BRACKET:
EFIS-400-W-480-DB-SK-40-EFX-DB-PTA-4090

LIGHT POLE

GENERAL NOTES:

1. ALL CONDUIT TO BE 3/4"GALVANIZED RIGID STEEL UNLESS OTHERWISE NOTED. WRAP OR COAT ALL STEEL CONDUIT THAT IS TO BE BURIED.
2. ALL WIRE TO BE #12 THHN UNLESS OTHERWISE NOTED ALL WIRE TO BE STRANDED COPPER. THE FOLLOWING COLOR CODING OF CONDUCTORS SHALL BE OBSERVED ON ALL 208Y/120V CIRCUITS:

	208Y/120V	480Y/277V
'A'PHASE (LEFT BUS IN PANEL)	BLACK	BROWN
'B'PHASE (CENTER BUS IN PANEL)	RED	ORANGE
'C'PHASE (RIGHT BUS IN PANEL)	BLUE	YELLOW
NEUTRAL	WHITE	GRAY
GROUND	GREEN	GREEN

3. PERMANENTLY LABEL ALL RECEPTACLES,JUNCTION BOXES, SWITCHES,ETC. WITH CIRCUIT IDENTIFICATION.
4. INSTALL REVISED PANEL SCHEDULES UPON COMPLETION OF JOB.

REFERENCE DRAWINGS

3.YD-E502 DETAILS

CONSTRUCTION NOTES

1 PROVIDE NEW LIGHT POLE.
2 PROVIDE TWO NEW FIXTURE ON EXISTING POLE.

20' 10' 0 20' 40'
SCALE IN FEET

										E13	E12	E11	E10
								E19	E18	E17	E16	E15	E14
							E27	E26	E25	E24	E23	E22	E21	E20
E53	E52			E37	E36	E35	E34	E33	E32	E31	E30	E29	E28
E51	E50	E49	E48	E47	E46	E45	E44	E43	E42	E41	E40	E39	E38

KEY PLAN
SCALE : NONE

URS
1501 4TH AVENUE, STE. 1400
SEATTLE, WA 98101-1616
TELEPHONE (206) 438-2700

SYM	REVISION	BY	APPROVED	DATE	SYM	REVISION	BY	APPROVED	DATE
A	PHASE 2 RE-ROUTE STORMWATER LINES - 60% DESIGN	URS	GIBSON	04.29.11					
B	PHASE 2 RE-ROUTE STORMWATER LINES - 90% DESIGN	URS	GIBSON	05.27.11					
C	PHASE 2 RE-ROUTE STORMWATER LINES - 100% DESIGN	URS	GIBSON	06.24.11					

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ACCEPTABILITY
THIS DESIGN AND/OR SPECIFICATION IS APPROVED

APPROVED BY	DEPT.	DATE

		DATE
DRAWN	OLSZEWSKI	06.24.11
CHECKED		
ENGINEER	GIBSON	06.24.11
CHECKED		
APPROVED		
APPROVED		

SUBTITLE: LIGHTING

TITLE: PHASE 2 RE-ROUTE STORMWATER LINES
NORTH BOEING FIELD

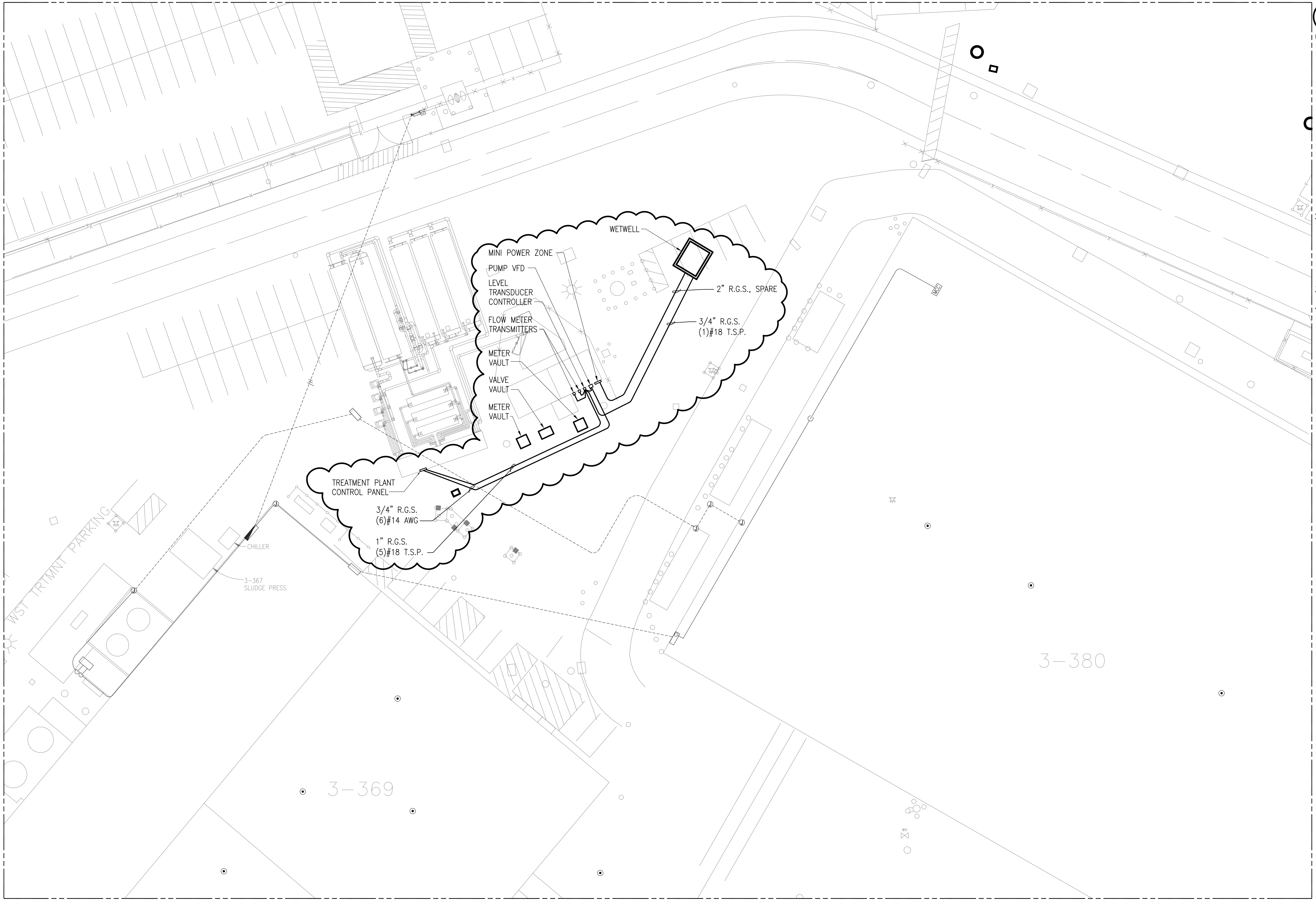
ELECTRICAL MASTER COL. NBF

CURRENT REVISION | SYMBOL: D | DATE: 06.24.11

SHEET: E16

JOB NO. | COMP NO.

DWG NO.: 3.YD-E16



LEGEND

208Y/120V NEW UG CONDUIT RUN

CONDUIT BENT DOWN OR AWAY CONDUIT

GENERAL NOTES

1. ALL CONDUIT TO BE 3/4"GALVANIZED RIGID STEEL UNLESS OTHERWISE NOTED. WRAP OR COAT ALL STEEL CONDUIT THAT IS TO BE BURIED.
2. ALL WIRE TO BE #12 THHN UNLESS OTHERWISE NOTED ALL WIRE IS TO BE STRANDED COPPER. THE FOLLOWING COLOR CODING OF CONDUCTORS SHALL BE OBSERVED ON ALL 208Y/120V CIRCUITS:
   'A'PHASE (LEFT BUS IN PANEL) BLACK
   'B'PHASE (CENTER BUS IN PANEL) RED
   'C'PHASE (RIGHT BUS IN PANEL) BLUE
   NEUTRAL WHITE
3. PERMANENTLY LABEL ALL RECEPTACLES,JUNCTION BOXES, SWITCHES,ETC. WITH CIRCUIT IDENTIFICATION.
4. INSTALL REVISED PANEL SCHEDULES UPON COMPLETION OF JOB.

REFERENCE DRAWINGS

CONSTRUCTION NOTES

20' 10' 0 20' 40'

SCALE IN FEET

										E63	E62	E61	E60
								E69	E68	E67	E66	E65	E64
						E77	E76	E75	E74	E73	E72	E71	E70
E103	E102			E87	E86	E85	E84	E83	E82	E81	E80	E79	E78
E101	E100	E99	E98	E97	E96	E95	E94	E93	E92	E91	E90	E89	E88

KEY PLAN
SCALE : NONE

N

URS
1501 4TH AVENUE, STE. 1400
SEATTLE, WA 98101-1616
TELEPHONE (206) 438-2700

SYM	REVISION	BY	APPROVED	DATE	SYM	REVISION	BY	APPROVED	DATE
A	PHASE 2 RE-ROUTE STORMWATER LINES – 60% DESIGN	URS	GIBSON	04.29.11					
B	PHASE 2 RE-ROUTE STORMWATER LINES – 90% DESIGN	URS	GIBSON	05.27.11					
C	PHASE 2 RE-ROUTE STORMWATER LINES – 100% DESIGN	URS	GIBSON	06.24.11					

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ACCEPTABILITY
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APPROVED BY	DEPT.	DATE

DRAWN OLSZEWSKI	DATE 06.24.11
CHECKED	
ENGINEER GIBSON	06.24.11
CHECKED	
APPROVED	
APPROVED	

SUBTITLE
208Y/120V POWER & GROUNDING

TITLE
PHASE 2 RE-ROUTE STORMWATER LINES
NORTH BOEING FIELD

ELECTRICAL MASTER COL. NBF

CURRENT REVISION | SYMBOL D | DATE 06.24.11

SHEET E66

JOB NO. | COMP NO.

DWG NO. 3.YD–E66

LEGEND:

- 480Y/277 VOLT NEW UG CONDUIT RUNS
- 4160 VOLT NEW UG CONDUIT RUNS
- 26,000 VOLT SCL SERVICE
- 480Y/277V VOLT THREE PHASE LOAD
- TRANSFORMER
- PUMP
- CONTROL PANEL

GENERAL NOTES:

1 ALL CONDUIT TO BE 3/4"GALVANIZED RIGID STEEL UNLESS OTHERWISE NOTED.

2 ALL WIRE TO BE #12 THHN UNLESS OTHERWISE NOTED THE FOLLOWING COLOR CODING OF CONDUCTORS SHALL BE OBSERVED ON ALL 208Y/120V CIRCUITS:

'A'PHASE (LEFT BUS IN PANEL)	BLACK
'B'PHASE (CENTER BUS IN PANEL)	RED
'C'PHASE (RIGHT BUS IN PANEL)	BLUE
NEUTRAL	WHITE

3 DYMO LABEL ALL RECEPTACLES,JUNCTION BOXES, SWITCHES,ETC. WITH CIRCUIT IDENTIFICATION.

4 INSTALL REVISED PANEL SCHEDULES UPON COMPLETION OF JOB.

REFERENCE DRAWINGS:

3.YD-C85
3.YD-E4

3.YD-E500
3.YD-E501
3.YD-E502

CONSTRUCTION NOTES:

1 TREATMENT PLANT CONTROL PANEL. COORDINATE LOCATION WITH CLEARWATER DRAWINGS.

20' 10' 0 20' 40'
SCALE IN FEET

											E113	E112	E111	E110
									E119	E118	E117	E116	E115	E114
						E127	E126	E125	E124	E123	E122	E121	E120	
E153	E152			E137	E136	E135	E134	E133	E132	E131	E130	E129	E128	
E151	E150	E149	E148	E147	E146	E145	E144	E143	E142	E141	E140	E139	E138	

KEY PLAN
SCALE : NONE

Mod: 06/22/2011, 15:26 | Plotted: 06/24/2011, 10:44 | larry_jilles

O:\Boeing\NBF\PEL Remediation\Phase 2 Re-Route Storm Lines\R03\Elec\3-YD-E116 - 480V Medium Voltage.dwg

ALPA_OLSZEWSKI: 05/25/11 14:39

URS 1501 4TH AVENUE, STE. 1400 SEATTLE, WA 98101-1616 TELEPHONE (206) 438-2700

SYM	REVISION	BY	APPROVED	DATE	SYM	REVISION	BY	APPROVED	DATE
A	PHASE 2 RE-ROUTE STORMWATER LINES – 60% DESIGN	URS	GIBSON	04.29.11					
B	PHASE 2 RE-ROUTE STORMWATER LINES – 90% DESIGN	URS	GIBSON	05.27.11					
C	PHASE 2 RE-ROUTE STORMWATER LINES – 100% DESIGN	URS	GIBSON	06.24.11					

BOEING®

ACCEPTABILITY
THIS DESIGN AND/OR SPECIFICATION IS APPROVED

APPROVED BY	DEPT.	DATE

DRAWN	OLSZEWSKI	DATE 06.24.11
CHECKED		
ENGINEER	GIBSON	06.24.11
CHECKED		
APPROVED		
APPROVED		

SUBTITLE: 480V, MEDIUM VOLTAGE

TITLE: PHASE 2 RE-ROUTE STORMWATER LINES
NORTH BOEING FIELD

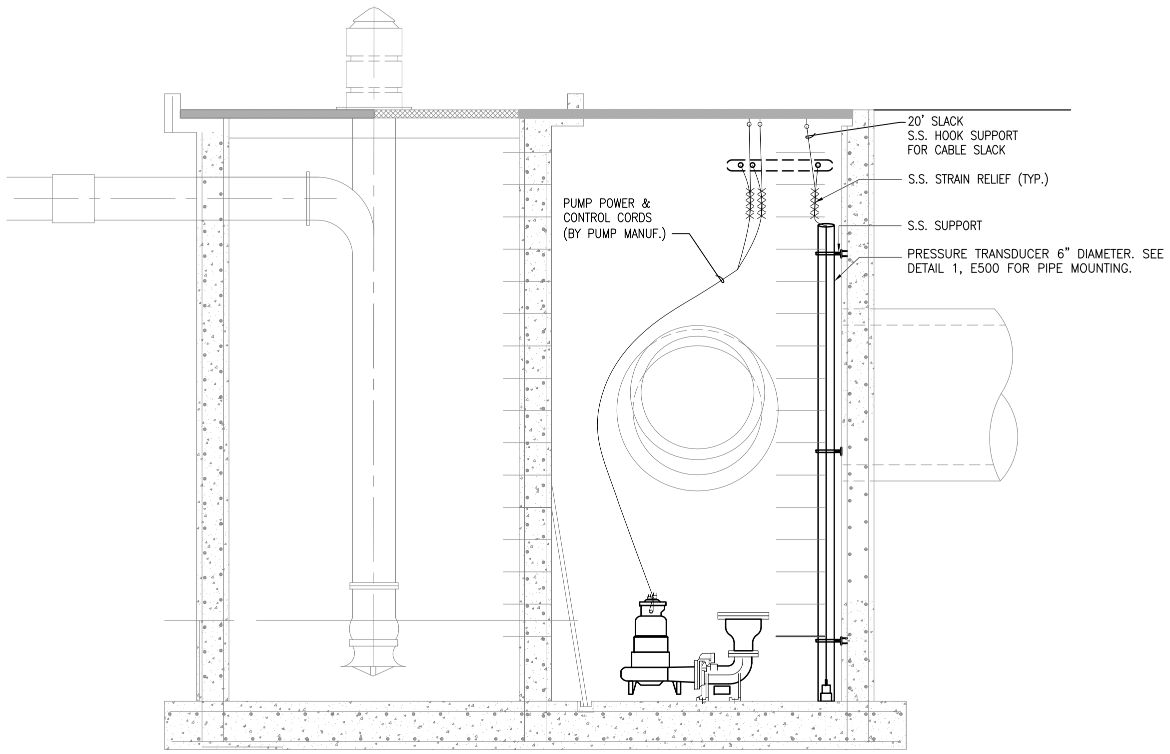
ELECTRICAL MASTER COL. NBF

CURRENT REVISION SYMBOL D DATE 06.24.11

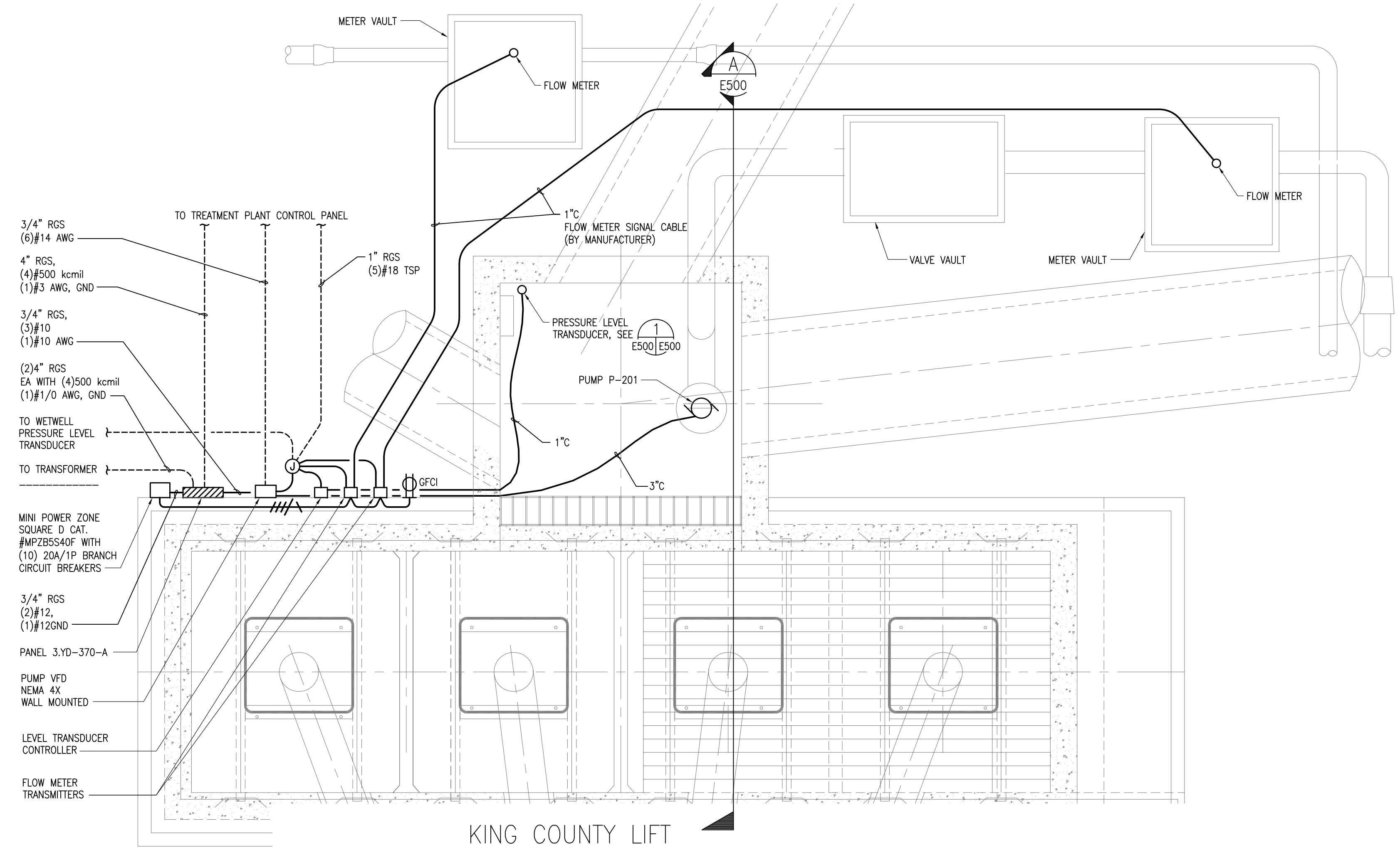
SHEET E116

JOB NO. COMP NO.

DWG NO. 3.YD-E116



KING COUNTY LIFT
STATION 431 SECTION
A
E500
SCALE: 3/8"=1'-0"



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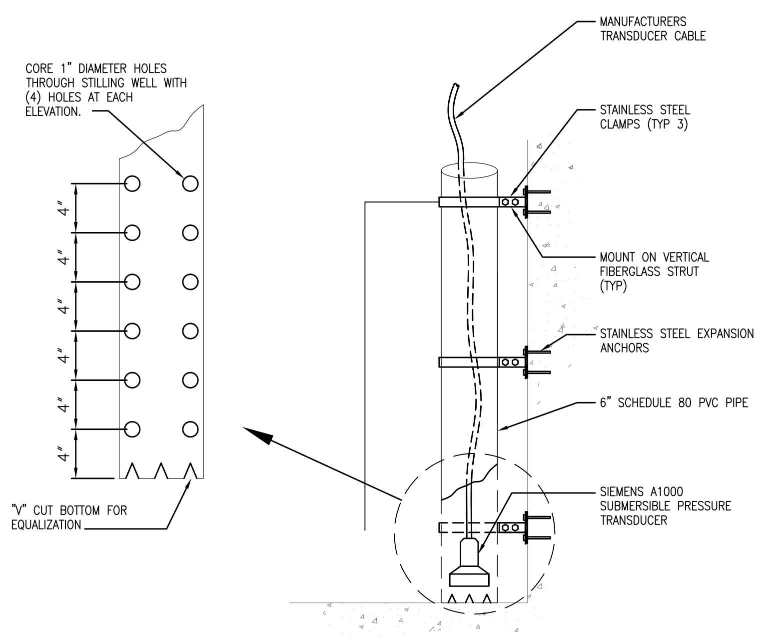

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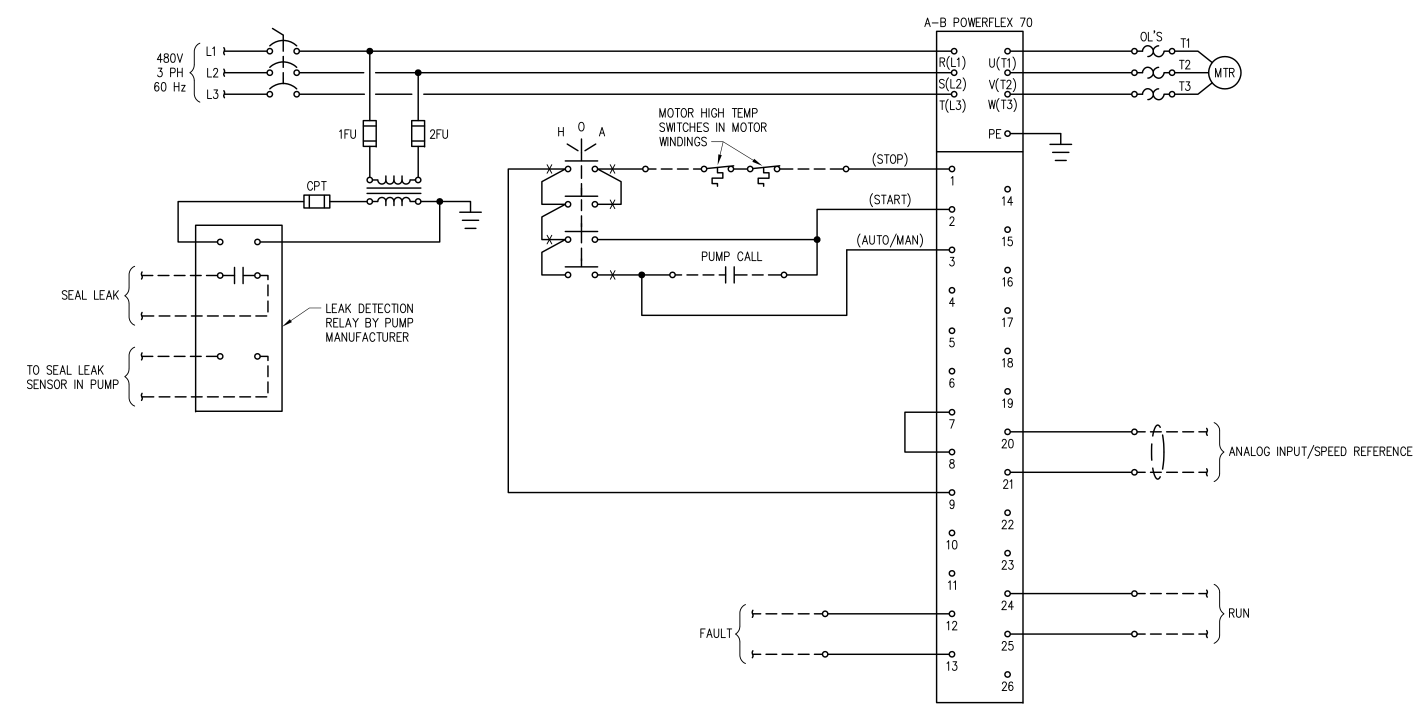

PUMP P-201 VFD

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B	PHASE 2 RE-ROUTE STORMWATER LINES – 90% DESIGN	URS	GIBSON	05.27.11					
C	PHASE 2 RE-ROUTE STORMWATER LINES – 100% DESIGN	URS	GIBSON	06.24.11					

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SUBTITLE: SECTIONS AND DETAILS
TITLE: PHASE 2 RE-ROUTE STORMWATER LINES
NORTH BOEING FIELD
ELECTRICAL MASTER COL. NBF

CURRENT REVISION: | SYMBOL: D | DATE: 06.24.11
SHEET: E500
JOB NO. 972108-00 | COMP NO.
DWG NO. 3.YD-E500

Mod: 06/24/2011, 08:31 | Plotted: 06/24/2011, 10:44 | larry_liles

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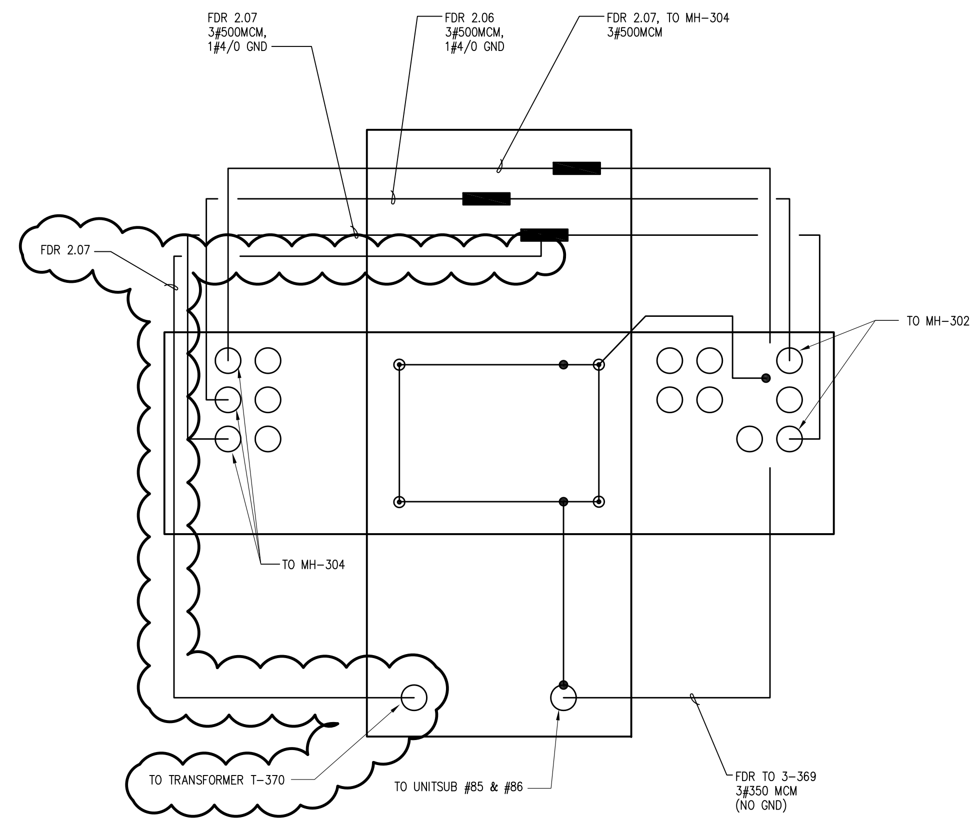

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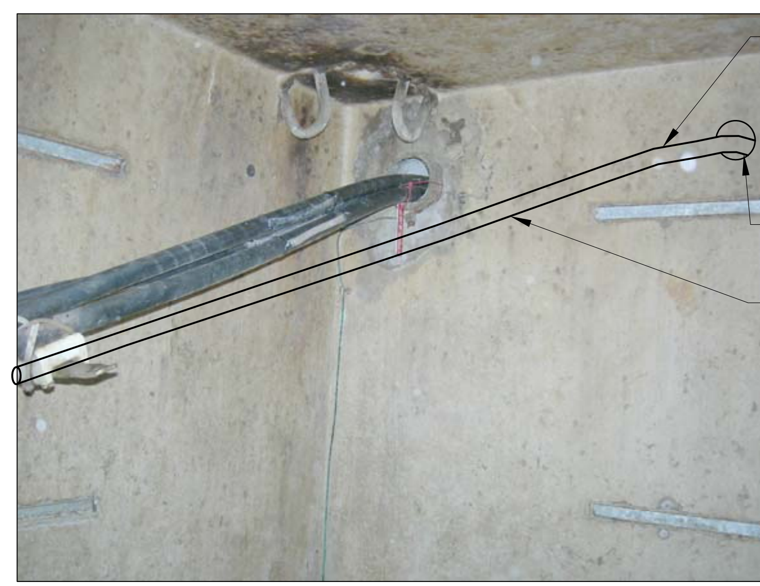

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C	PHASE 2 RE-ROUTE STORMWATER LINES – 100% DESIGN	URS	GISBON	06.24.11					

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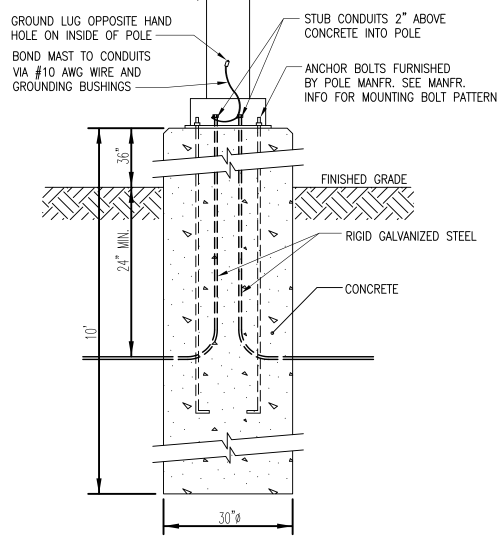
TITLE: PHASE 2 RE-ROUTE STORMWATER LINES
NORTH BOEING FIELD
ELECTRICAL MASTER COL. NBF

CURRENT REVISION SYMBOL: D
DATE: 06.24.11
SHEET: E501
JOB NO.: 972108-00
COMP NO.:
DWG NO.: 3.YD-E501



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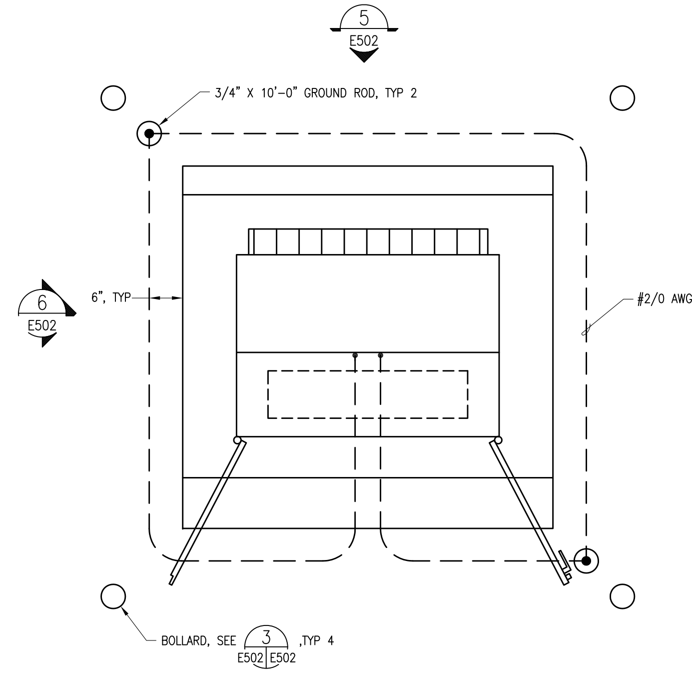

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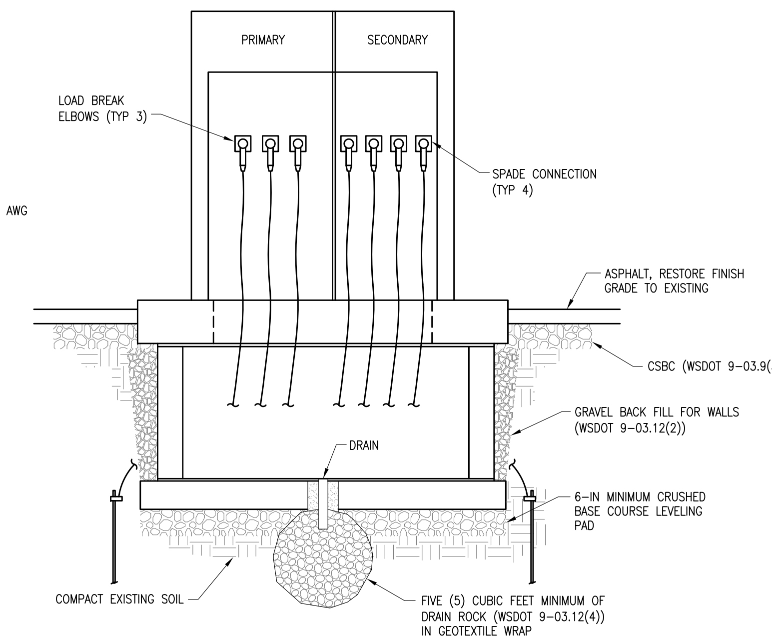

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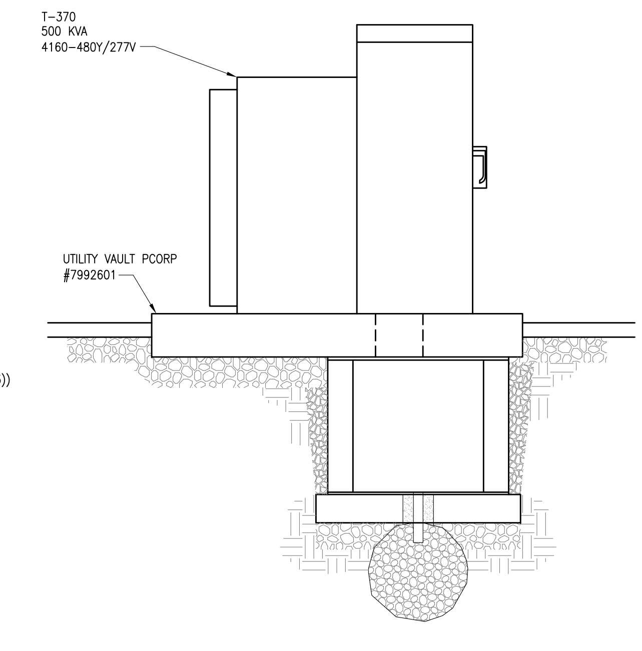

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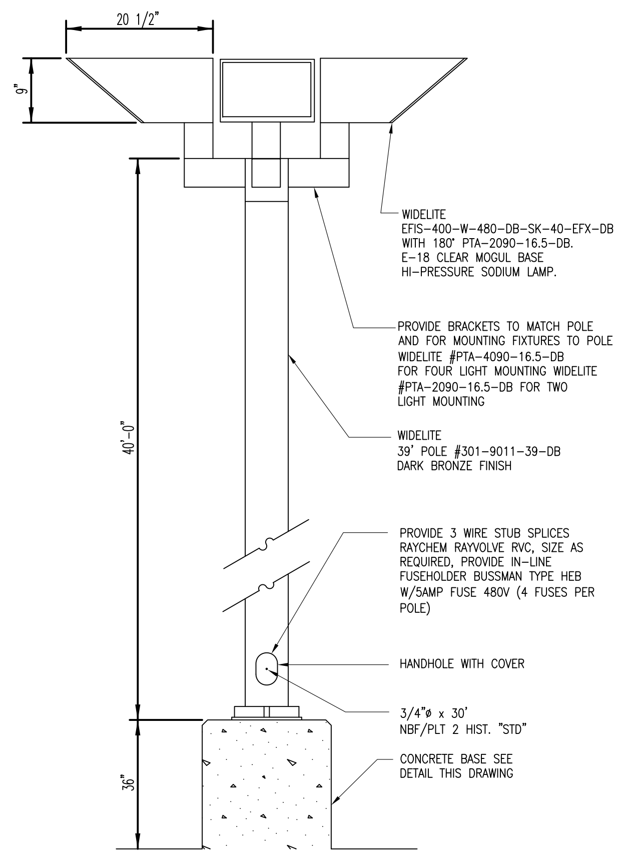

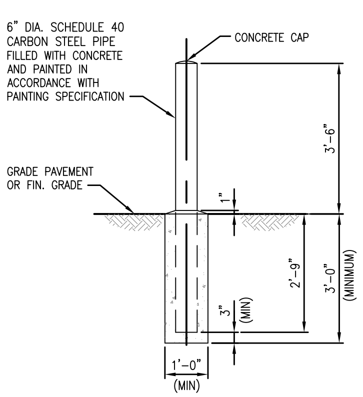

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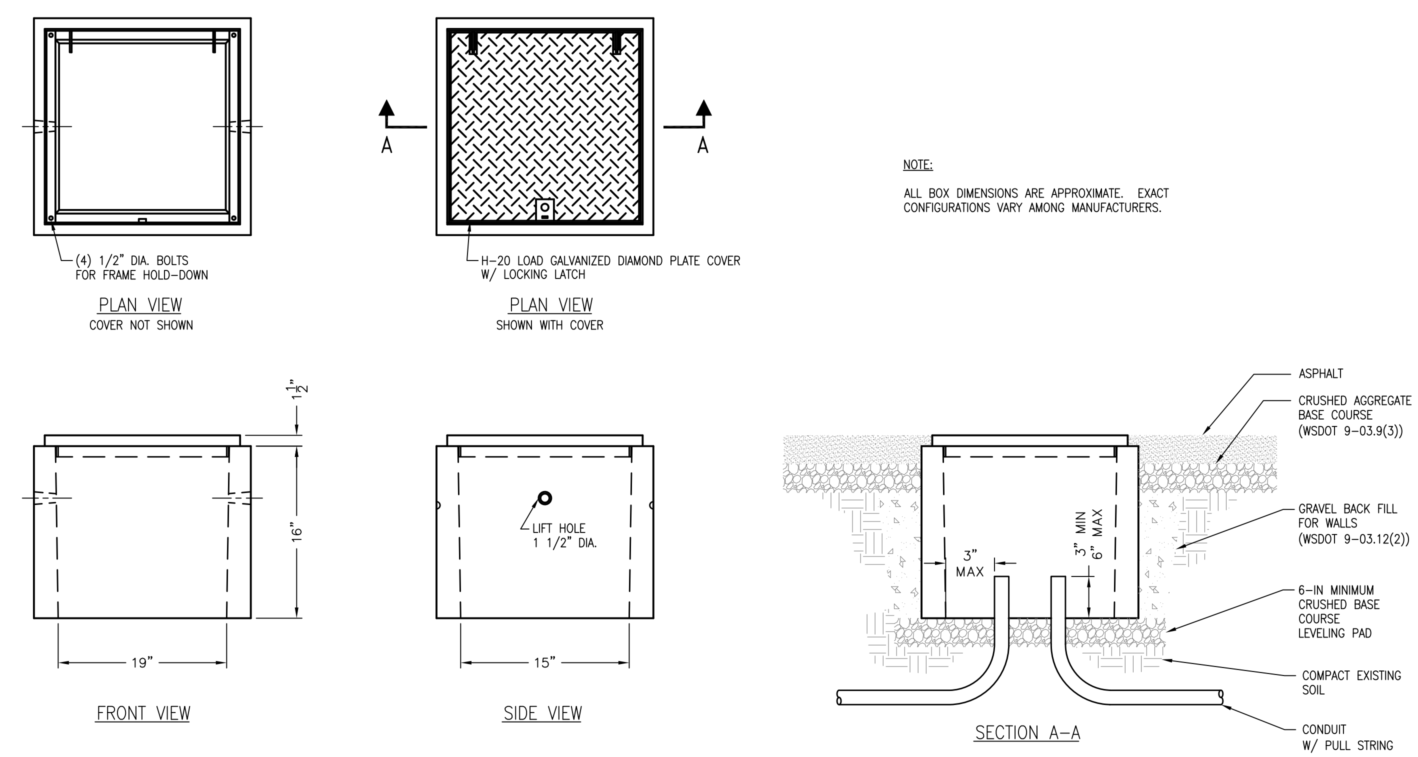

NOTE:
ALL BOX DIMENSIONS ARE APPROXIMATE. EXACT CONFIGURATIONS VARY AMONG MANUFACTURERS.

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SCALE: N.T.S.

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B	PHASE 2 RE-ROUTE STORMWATER LINES – 90% DESIGN	URS	GIBSON	05.27.11					
C	PHASE 2 RE-ROUTE STORMWATER LINES – 100% DESIGN	URS	GIBSON	06.24.11					

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SUBTITLE: DETAILS
TITLE: PHASE 2 RE-ROUTE STORMWATER LINES
NORTH BOEING FIELD
ELECTRICAL MASTER COL. NBF

CURRENT REVISION SYMBOL D DATE 06.24.11
SHEET E502
JOB NO. 972108-00 COMP NO.
DWG NO. 3.YD-E502

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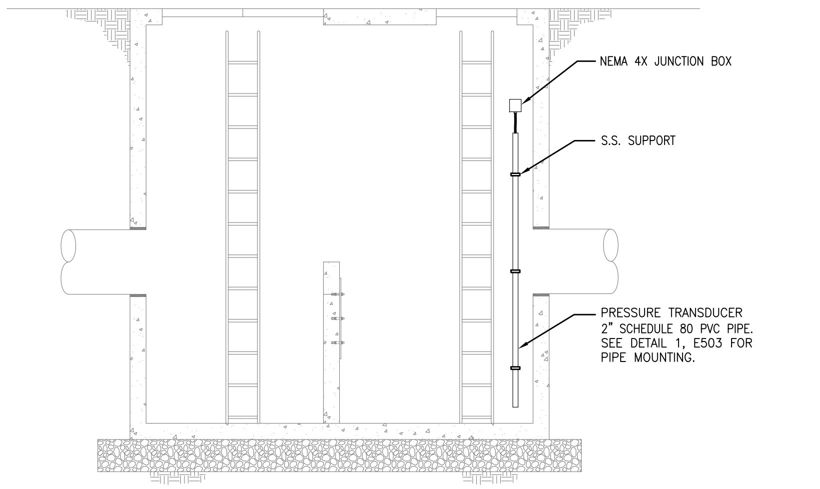

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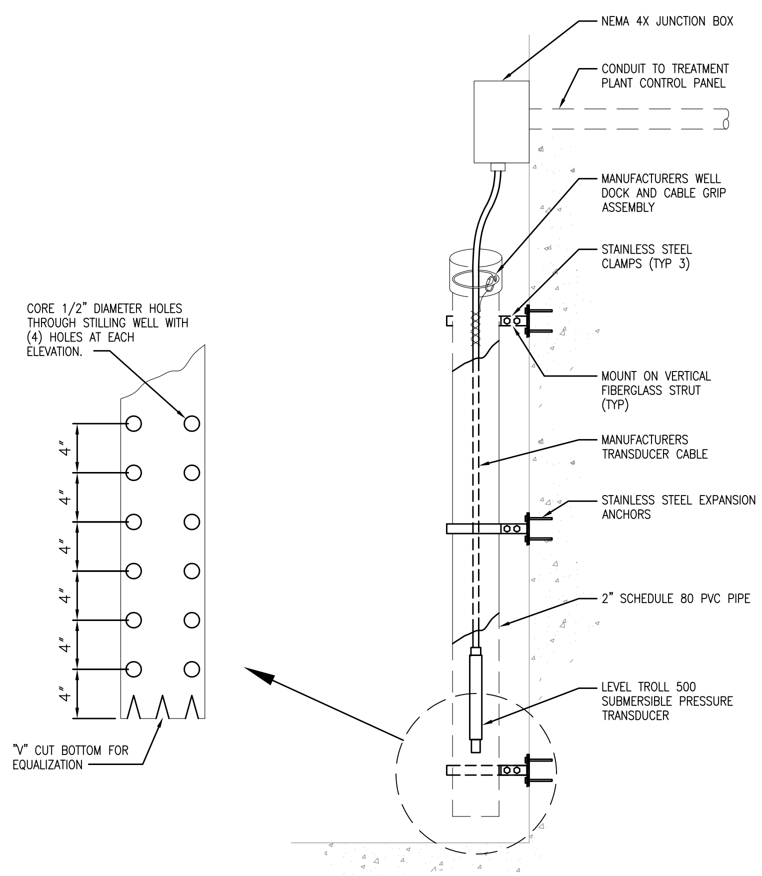

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B	PHASE 2 RE-ROUTE STORMWATER LINES – 90% DESIGN	URS	GIBSON	05.27.11					
C	PHASE 2 RE-ROUTE STORMWATER LINES – 100% DESIGN	URS	GIBSON	06.24.11					

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APPROVED		

SUBTITLE: SECTIONS AND DETAILS

TITLE: PHASE 2 RE-ROUTE STORMWATER LINES
NORTH BOEING FIELD

ELECTRICAL MASTER COL. NBF

CURRENT REVISION SYMBOL: D DATE: 06.24.11

SHEET: E503

JOB NO. 972108-00 COMP NO.

DWG NO. 3.YD-E503

Mod: 06/21/2011, 10:39 | Plotted: 06/24/2011, 10:45 | larry_lazo

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APPENDIX C

Sampling and Analysis Plan for Long-Term Stormwater Treatment

Sampling and Analysis Plan
Long-Term Stormwater Treatment
North Boeing Field
Seattle, Washington

June 24, 2011

Prepared for

The Boeing Company
Seattle, Washington

LANDAU ASSOCIATES
130 2nd Avenue South
Edmonds, WA 98020
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TITLE AND APPROVAL SHEET

APPENDIX C – SAMPLING AND ANALYSIS PLAN
LONG-TERM STORMWATER TREATMENT

NORTH BOEING FIELD, SEATTLE, WASHINGTON

<u>Quality Assurance Project Plan Approvals</u>

EPA Project Manager:	Karen Keeley		Date:
EPA QA Manager:	Ginna Grepo-Grove		Date:
Boeing Project Manager:	Carl Bach	Carl Bach	Date: June 23, 2011
Landau Associates Project Manager:	Kristy Hendrickson	Kristy Hendrickson	Date: June 24, 2011
Landau Associates Task Manager:	Joe Kalmar	Joe Kalmar Digitally signed by Joe Kalmar DN: cn=Joe Kalmar, o=Landau Associates, ou=Corp, email=jkalmar@landauinc.com, c=US Date: 2011.06.24 13:42:28 -07'00'	Date:
Landau Associates Project QA Coordinator:	Anne Halvorsen	Anne Halvorsen	Date: June 24, 2011
ARI Project Manager:	Kelly Bottem	Kelly Bottem	Date: June 24, 2011
ARI QA Manager:	Dave Mitchell	Dave Mitchell Digitally signed by Dave Mitchell DN: cn=Dave Mitchell, o=ARI Labs, Inc., ou=QA, email=davem@arilabs.com, c=US Date: 2011.06.24 10:21:30 -07'00'	Date: June 24, 2011

TABLE OF CONTENTS

FIGURES

Figure	Title

TABLES

Table	Title

LIST OF ABBREVIATIONS AND ACRONYMS

µg/L	Micrograms per Liter
µg/kg	Micrograms per Kilogram
µm	Micron
AKART	All Known, Available, and Reasonable Methods of Prevention, Control, and Treatment
ASAOC	Administrative Settlement Agreement and Order on Consent
Boeing	The Boeing Company
C	Celsius
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CESF	Chitosan-Enhanced Sand Filtration
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
CPR	Cardiopulmonary Resuscitation
CSV	Comma Separated Value
DQOs	Data Quality Objectives
EAA	Early Action Area
Ecology	Washington State Department of Ecology
EDD	Electronic Data Deliverable
EOF	Emergency Overflow
EPA	U.S. Environmental Protection Agency
FSP	Field Sampling Plan
gpm	Gallons per Minute
GTSP	Georgetown Steam Plant
HASP	Health and Safety Plan
KBFI	Seattle Boeing Field-King County International Airport Rain Gauge
KCIA	King County International Airport
LDW	Lower Duwamish Waterway
LTST	Long-Term Stormwater Treatment
mg/L	Milligrams per Liter
mL	Milliliter
MQOs	Measurement Quality Objectives
MS	Matrix Spike
MSD	Matrix Spike Duplicate
NBF	North Boeing Field
NELAC	National Environmental Lab Accreditation Conference
NOAA	National Oceanic and Atmospheric Agency
NPL	National Priorities List
OSHA	Occupational Safety and Health Administration
PCBs	Polychlorinated Biphenyls
ppb	Parts per Billion
PSDDA	Puget Sound Dredged Disposal Analysis
PSEP	Puget Sound Estuary Program
psi	Pounds per Square Inch
PVC	Polyvinyl Chloride
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RPD	Relative Percent Difference

SAP	Sampling and Analysis Plan
SAIC	Science Applications International Corporation
SM	Standard Method
STST	Short-Term Stormwater Treatment
SVOCs	Semivolatile Organic Compounds
TSS	Total Suspended Solids
WAC	Washington Administrative Code
WISHA	Washington Industrial Safety and Health Act

1.0 INTRODUCTION

This document presents a sampling and analysis plan (SAP) for the operation and maintenance of the long-term stormwater treatment (LTST) system being installed as part of a removal action being conducted by The Boeing Company (Boeing) at the North Boeing Field (NBF) site in Seattle, Washington (Figure 1). The purpose of the removal action is to control contaminant discharges from the NBF site to the Slip 4 Early Action Area (EAA) of the Lower Duwamish Waterway (LDW) Superfund Site. The removal action is being conducted under an Administrative Settlement Agreement and Order on Consent (ASAOC) for Removal Action [Docket No. Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)-10-2010-0242] between Boeing and the U.S. Environmental Protection Agency (EPA). The ASAOC requires that a SAP be prepared for collection and analysis of stormwater compliance monitoring samples and any other samples related to the removal action; this SAP is an appendix to the *100% Design, Long-Term Stormwater Treatment, North Boeing Field, Seattle, Washington*. As defined in the *Action Memorandum for the Time-Critical Removal Action at North Boeing Field*, "stormwater" shall mean all liquids, including any particles dissolved therein, in the form of base flow, stormwater runoff, snow melt runoff, and surface runoff and drainage, as well as all solids that enter the storm drainage system. "System," when used in the context of storm drainage, shall mean the combination of all manholes, catch basins, pipes, and other drainage devices and conveyances designed, constructed, and used for the purpose of carrying stormwater from NBF to Slip 4 of the LDW, and the drainage basin associated with these devices and conveyances (EPA 2010).

This SAP is comprised of a Field Sampling Plan (FSP) and a project-specific Quality Assurance Project Plan (QAPP). The FSP (Section 2.0) identifies the sampling objectives and describes the sampling and analysis procedures and methodologies to achieve the sampling objectives. The QAPP (Section 3.0) identifies data quality objectives (DQOs) for the project and describes the quality assurance (QA) and quality control (QC) protocols necessary to achieve the DQOs.

1.1 PROJECT SITE DESCRIPTION

NBF is located east of East Marginal Way South, adjacent to the King County International Airport (KCIA) and the city of Seattle Georgetown Steam Plant (GTSP). The approximate street address is 7370 East Marginal Way South, Seattle, Washington. NBF is approximately 150 ft from the head of Slip 4, which is an EAA at approximately River Mile 2.8 on the Duwamish Waterway within the LDW Superfund Site. The location of the site is shown on Figure 1.

1.2 PROJECT BACKGROUND

In 2001, the LDW was placed on the National Priorities List (NPL) pursuant to CERCLA. In 2003, the sediments and portions of the bank in Slip 4 were identified as an EAA due to the presence of polychlorinated biphenyls (PCBs) in the sediment. Prior to cleanup of Slip 4, the Washington State Department of Ecology (Ecology) determined that ongoing sources of PCB discharges to Slip 4 should be controlled to reduce the likelihood of recontamination of the sediment following cleanup. Previous investigations at the NBF site identified the presence of PCBs in solids in manholes, catch basins, sediment traps, and water in the NBF storm drain system, which discharges to Slip 4 via the KCIA Storm Drain #3/PS44 Emergency Overflow (EOF) as indicated on Figure 2.

As reported by Science Applications International Corporation (SAIC 2010a,b,c; SAIC 2009), the majority of PCBs discharging from NBF to Slip 4 via the NBF storm drain system are from the north lateral portion of the storm drain. Under the ASAOC, Boeing installed a short-term stormwater treatment (STST) facility to remove PCBs from stormwater from the north lateral of the NBF storm drain system prior to discharge to Slip 4. The STST facility was placed into continuous operation on September 15, 2010 and will continue to be operated under the oversight and direction of EPA until the LTST facility is installed and operating. During operation of the STST facility, samples of the storm drain system solids and stormwater have been collected to monitor compliance with the interim goals established by EPA for the STST facility, to evaluate performance of the STST facility, and to support design of the LTST facility.

1.3 COMPLIANCE MONITORING DURING STST OPERATION

Site-wide monitoring performed under the STST Removal Action Work Plan (Landau Associates 2011) consisted of weather forecast monitoring in order to target qualifying storm events and base-flow events, and collecting samples at multiple locations at the site when qualifying conditions were met. Sampling locations were at Lift Station 431 (LS431) and at Manhole 108 (MH108). These sampling locations, as well as the location of the STST facility, are shown on Figure 2.

For sampling at LS431 and MH108, a qualifying storm event was defined as "a 24-hour period with 0.15 inch or more of rain over a period of at least 5 hours, preceded by at least 24 hours of no greater than a trace amount (0.04 inch) of precipitation" (Landau Associates 2011). EPA later approved reduction of the amount of rainfall required to 0.10 inch and reduction of the antecedent dry period to at least 12 hours. In practice, sampling events under so strictly defined limits proved difficult. Many qualifying storms failed to produce sufficient rainfall, and many storms that would have qualified were not predicted. In addition, some samples from qualifying storms were not usable due to a large difference in the predicted compared to the actual amount of precipitation. Flow-weighted whole-water composite sampling requires predicting a volume interval (based on precipitation forecasts) on which to collect aliquots. When predicted flow does not match actual flow, the whole water sample carboy may be filled too early or the sampler may not take enough aliquots during the prescribed time period to have enough water for analysis. Base-flow events were defined as two or more consecutive days of less than trace (0.04 inch) precipitation, preceded by at least 12 hours of less than trace (0.04 inch) precipitation. These events were also difficult to predict. Some events were underway, only to be disqualified by unexpected rainfall.

PCB data for storm and base-flow events at LS431 and MH108 from November 2010 through March 2011 are presented in Table 1 and plotted against precipitation during the sampling period on Figure 3 (whole water) and Figure 4 (filtered solids). The data do not show a correlation between precipitation and concentration of PCBs in whole water at either LS431 or MH108. The data also do not show a correlation between precipitation and concentration of PCBs in filtered solids at MH108, although there is a slight positive correlation for filtered solids at LS431.

Targeting specific precipitation conditions for sampling does not give representative data on all discharge to Slip 4; it instead gives representative data for those specific conditions that are targeted. Based on the results from site-wide monitoring during STST system operation, other sampling approaches were investigated. The main objective of compliance monitoring during LTST operation is to evaluate compliance with the interim goals (Section 1.4) for all discharge. Therefore, routine sampling during LTST operation will not target specific 24-hour storm events or base-flow events. Instead, flow-weighted composite water sampling and concurrent filtered solids sampling over multiple days will be implemented on a fixed monthly interval, regardless of precipitation conditions. This will result in sampling during an array of precipitation conditions, will make sampling more straightforward to coordinate and perform, and will result in samples that are representative of overall stormwater discharge to Slip 4.

However, there is a potential for all scheduled monthly sampling events to coincide with relatively dry periods, and sampling may never take place during bypass of the LTST system (from larger or more intense precipitation events). As the LTST facility is treating 100 percent of base flow, but will have bypass of a portion of storm flow from on site and off site, it is important that monitoring include periods of heavier rainfall and LTST system bypass. To increase the likelihood that at least some monitoring will take place during bypass events, two storm events will also be targeted over the course of the sampling period. The storm events that will be targeted will have a predicted rainfall of 0.5 inches or more in a 24-hour period. These events will fulfill the requirements for the two storm event samples if rainfall during the sampling event (to be 24 hours or less) exceeds 0.5 inches, if precipitation in the preceding 12 hours is 0.04 inches or less, and if the LTST system is bypassed at any time during the sampling event. Although these events may occur at any time over the course of the sampling period, targeting of these events will begin at the beginning of the sample period (September 30, 2011), as larger storms are more likely to occur in the autumn and early winter months.

When STST system operation began, TSS concentrations were analyzed in whole water samples and calculated (using the mass of solids collected in a filter bag and the volume of stormwater filtered through that bag, as measured by the flow totalizer). This was done for site-wide compliance monitoring as well as STST system performance monitoring. However, the two TSS measurements consistently disagreed significantly. The calculated TSS measurement was determined to be unreliable due to a lack of confidence in the reliability of data collection methods, and reporting of calculated TSS was discontinued. The more accurate whole water TSS concentration will continue to be the only TSS concentration reported during LTST monitoring.

1.4 INTERIM GOALS FOR LTST SYSTEM OPERATION

Interim goals for the LTST facility have been set by EPA and are as follows:

- Water discharged to Slip 4 must be below the Aquatic Life – Marine/Chronic water quality standard of 0.030 micrograms per liter (µg/L) total PCBs. Boeing conducted (AMEC Geomatrix, Inc. 2011) and EPA approved (EPA 2011) a salinity study in Slip 4 which demonstrates that use of the Marine/Chronic water quality standard for total PCBs is appropriate.
- In-line storm drain solids discharged to Slip 4 must be below 100 parts per billion (ppb) dry weight total PCBs. This interim goal shall be used as a point of departure in considering whether the long-term interim goal for in-line storm drain solids discharged to Slip 4 should be modified in accordance with the all known, available, and reasonable methods of prevention, control, and treatment (AKART).

Evaluations are ongoing by EPA to determine the applicability of the 100 ppb PCB solids interim goal, and whether that interim goal will be modified as a result of the AKART analysis. Like the STST facility, the LTST facility will remove total suspended solids (TSS) and associated PCBs from stormwater in the north lateral of the NBF storm drain system using a chitosan enhanced sand filtration (CESF) system. In addition, the LTST facility will treat all base flow and a portion of stormwater runoff during storm events from the other NBF storm drain laterals that drain to LS431 (the south, south central, north central, and 3-380 building laterals). The LTST facility will be installed and operating by September 30, 2011; it will be designed, installed, operated, and maintained under EPA oversight.

2.0 FIELD SAMPLING PLAN

This FSP presents the sampling objectives related to the LTST removal action being conducted at the site; proposed sample locations; and the sample collection methodologies, frequency, and laboratory analyses.

2.1 SAMPLING OBJECTIVES

The objectives of the field sampling are to gather data to accomplish the following:

- Monitor compliance with the LTST interim goals
- Evaluate the performance of the LTST facility.

2.2 SAMPLING LOCATIONS

To meet the sampling objectives identified in Section 2.1, stormwater and solids samples will be collected from the NBF storm drain system at the following locations:

- **Lift Station (LS431) – Compliance Monitoring Point**. As discussed in the main text and in previous reports (Geosyntec Consultants and Landau Associates 2011), the point of compliance for the LTST interim goals (described in Section 1.4) is identified as just downstream of the King County lift station pumps. This point will also be downstream of the LTST system effluent discharge. Compliance monitoring at this location will consist of collecting flow-weighted whole water and filtered solids samples for laboratory analysis.
- **LTST System Influent and Effluent**. To monitor the performance of the LTST facility, whole water samples of the treatment facility influent and effluent, and filtered solids samples from the treatment facility influent and effluent, will be collected for laboratory analysis. The influent to the LTST facility from MH130A (the north lateral) will be sampled independently from the influent to the LTST facility from the LS431 inlet vault (all other laterals).
- **LTST Weir Tanks, Storage Tanks, and Sand Filters.** Samples will be collected of solids retained in the inlet weir and backflush settling tanks (both approximately 18,000-gallon capacity tanks) and storage tanks (each approximately 21,000-gallon capacity), as needed, to determine appropriate disposal options for the solids. The thickness of the solids in each tank will be checked monthly. If the average thickness of accumulated solids is above the trigger levels described in Section 2.6, a composite sample of the solids will be collected to allow for proper waste characterization and disposal. Composite samples of sand filter media will be collected for waste characterization prior to disposal as described in Section 2.6.
- **Sediment Traps.** To continue to evaluate individual lateral storm drain inputs, Boeing will continue the sediment trap monitoring program that began in 2005. This will consist of collecting solids from sediment traps at locations SL4-T1, SL4-T2, SL4-T3, SL4-T4, SL4-T5, SL4-T4A, and SL4-T5A, although the current location of SL4-T5A in MH178 will need to be moved to the "buried" manhole upstream of MH178 (or other storm drain structure in the re-routed line) because the King County storm drainage to the North lateral will be diverted at this location, as shown on Figure 5 and on the design plans. It is expected that the city of Seattle will continue to monitor other sediment traps outside of the NBF property boundary (SL4-T1A, SL4-T2A, and SL4-T3A) that are located on storm drain lines entering the NBF site.

- **Re-routed Storm Drain Pipe from King County.** In order to determine if the re-routed stormwater from King County is contributing to an inability of the LTST system to meet the EPA interim goals, water quality sampling and flow rate monitoring will be performed on this re-routed storm drain line. The precise sampling location is to be determined, as described in Section 2.7.

The locations of LS431, the LTST facility, and the sediment traps are shown on Figure 5. Also shown is the location at which offsite King County stormwater is to be re-routed. The more detailed project drawings of the LTST facility identifying the inlet weir tank, storage tanks, backflush settling tank, two influent sampling locations, and effluent sampling location are provided in Appendix A of the 100% Design Report.

2.3 LIFT STATION (LS431) SAMPLING

Sampling at LS431 will consist of collecting flow-weighted composite whole water samples and filtered solids samples from stormwater at the monitoring point of compliance (LS431 discharge outlet pipe). This section describes the sampling devices, sample collection methods, frequency of sample collection, and laboratory analyses.

2.3.1 SAMPLING FREQUENCY

To evaluate compliance with the LTST facility goals, stormwater and solids samples will initially be collected monthly from LS431 between September 30, 2011 and April 30, 2012. These seven sampling events will take place over multiple days, in order to obtain representative samples of water and solids discharged to Slip 4 and to facilitate straightforward sample collection. Setup will take place and sampling will commence on the first Monday of the month. In order to collect composite samples over a time period that will include a variety of stormwater flow conditions, volume intervals for flow-weighted whole water sampling will be calculated based on weather forecasts for the period starting Monday and continuing through the following Thursday. Actual precipitation will vary from the predicted amount used to calculate the volume interval, and some weeks sample collection may occur before Thursday due to earlier than anticipated filling of the 5-gallon glass carboy. Sample collection may also occur after Thursday due to drier than anticipated conditions. If enough water has been collected to run the required analysis, sample collection will occur on Friday in order to deliver the sample to the laboratory by 4:00 pm, to avoid after-hours laboratory coordination. Samples will not be collected earlier than the Thursday following setup, unless the sample carboy was filled prior to that time due to heavier than expected stormwater flow conditions. If the week of the month that includes the first Monday also includes a holiday, sampling will instead take place the following week. After the April 2012 sampling event, Boeing will propose to EPA a sampling frequency based on the results from the initial 7 sampling events.

In addition, to ensure that at least some monitoring of LS431 discharge takes place during LTST system bypass conditions, 24-hour storm events with predicted rainfall of 0.5 inches or greater will be targeted to attempt to conduct sampling during a period when bypass of the LTST system is likely to occur. Two of these events, weather permitting, will be sampled by April 30, 2012. Although these events may occur at any time over the course of the sampling period, targeting of these events will begin at the beginning of the sample period (September 30, 2011), as larger storms are more likely to occur in the autumn and early winter months. Requirements for these two events are precipitation of 0.5 inches or greater in the sampling event (24 hours or less), an antecedent dry period (0.04 inches precipitation or less) of at least 12 hours, and indication that bypass of the LTST system occurred during the sampling event.

A summary of the planned sampling at the LS431 during operation of the LTST facility is provided in Table 2.

2.3.2 SAMPLING DEVICES

This section describes the sampling devices that will be used to collect the whole water and solids samples at LS431. The methodology for positioning these devices at the LS431 discharge outlet pipe is also described. It should be noted that the installation and some potential maintenance of the stormwater and solids sampling equipment will require confined space entry.

2.3.2.1 Whole Water

Whole water samples of the stormwater at LS431 will be collected using an ISCO 6712 automated sampler with a jumbo base, or similar equipment. Each whole water stormwater sample collected will be a flow-weighted composite collected in a 5-gallon laboratory-cleaned glass carboy located in the base of the ISCO unit. The sample collected in the carboy will consist of equal volume aliquots sampled at predetermined runoff volume intervals. When collecting a flow-weighted composite sample, aliquots will be collected more frequently at high flow rates and less frequently at low flow rates. The volume interval between aliquots for each sampling event will be calculated using the anticipated volume of runoff for the period to be sampled. For the 24-hour storm events, a regression line based on data from past sampling events that plots predicted inches of rainfall versus total runoff will be used to estimate the runoff for the upcoming sampling event, based on the inches of predicted rainfall. For the routine monthly sampling events, the volume interval will be calculated using the same regression line if storms are predicted for the sampling period; if possible, runoff from each individual storm in the sampling period will be calculated and totaled. Data on seasonal base flow rates will be used for predicted dry conditions to estimate an appropriate volume interval during predicted base flow conditions. As the sampling period will be longer than previously conducted, and some sample events will likely incorporate both storm events and base flow conditions, some adjustment of the procedures for volume interval calculation will likely be needed. New regression lines will be generated to attempt to produce more accurate runoff predictions.

The sampler will be equipped with a Model 750 Area Velocity Flow Module or similar equipment. Flow will be measured continuously at 1-minute intervals. The ISCO unit will be programmed to collect aliquots of stormwater based on the predetermined volume interval and the data it receives from the Flow Module.

Once the automated sampler has been programmed according to the predicted runoff for the sampling event and the laboratory-cleaned glass carboy is in place, the sampling program will be started. Specific details on installation and programming of the ISCO 6712 stormwater samplers can be found in the 6712 Portable Samplers Installation and Operation Guide (Teledyne Isco 2010) and the 750 Area Velocity Module Installation and Operation Guide (Teledyne ISCO 2009). All field personnel will be familiar with these documents.

The stormwater collected for laboratory analysis will be drawn from the 48-inch LS431 outlet pipe, downstream of the King County lift station pumps and the LTST system discharge. A peristaltic pump attached to the autosampler and a Teflon® suction line will be used to draw water from the outlet pipe. The intake of the suction line will be connected to a stainless-steel strainer to remove any large debris. The strainer will be attached to an expanding scissors ring with a diameter matching the outlet pipe dimensions. The area/velocity flow sensor will either be attached to the same scissors ring or to a separate scissors ring in the next downstream catch basin (CB433), if a submerged sensor is to be used. The scissors ring holding the sensor will be placed at least one pipe diameter (48 inches) downstream of the opening of the LS431 outlet pipe, or alternatively at least one pipe diameter (60 inches) upstream of the opening of the CB433 inlet pipe. Installation will require confined space entry. Prior to placement of the expanding ring(s), any accumulated solids will be scraped off the pipe walls to ensure the ring will create a firm seal. The flow sensor will be installed so that it faces upstream and is oriented at the bottom of the pipe. The strainer will also be installed facing upstream and situated so that the intake screen is near, but not touching, the surface of the pipe to avoid excess sediment accumulation. The strainer will be positioned near the bottom of the pipe so that it is completely underwater during stormwater discharge, otherwise aliquots will not be able to be collected during lower discharge flow rates; if there is air in the suction line, the ISCO may reject the aliquot. The suction line and sensor cord will be secured to the scissors ring and to other pipe and permanent fixtures using plastic zip-ties. The suction line will be installed in a manner that does not allow it to kink under higher velocity flows and in a manner that does not allow loops to form, so that the peristaltic pump can work properly and bubbles do not form in the suction line. If it is necessary to shorten the suction line during installation, the exact length of the line will be recorded in the field logbook and the sampler will be (re)programmed with the corrected length.

After the sensor and electrical cords have been attached to the autosampler, the sampler will be plugged into the nearest AC power source and the autosampler will go through a self check process. If the check is acceptable, the autosampler will be left in place in a weatherproof shed for flow data collection. Field personnel will also calibrate the autosampler peristaltic pump to ensure the appropriate number of pump turns produces the desired aliquot volume. The autosampler will be set to purge the suction line before and after collecting each aliquot. Following calibration of the pump, the suction line will be connected to the pump and the autosampler.

2.3.2.2 Solids

Solids samples from LS431 stormwater will be collected using an in-line stormwater filtration system. The system will consist of a submersible pump that will push water upward through two filters housed in canisters. The pump will be a Dayton model 4HU70 ½ hp effluent pump or similar, and the filter housings will be FSI model CBFP-11 carbon steel units. A flow totalizer will measure the volume of water passing through each filter, and a pressure gauge will indicate when the filter bags need to be replaced. The filtration design will include parallel filter housings, each equipped with a 16-inch-long, 7-inch-diameter filter bag with a Polyloc® seal to prevent bypass. All bags will be made of 1 micron (μm) polypropylene felt.

The pump will be positioned in the LS431 discharge vault, just to the side of the outlet pipe (upstream of the stormwater autosampler flow sensor and suction line intake) and anchored to the vault ladder to prevent movement of the pump during high flow events. Ideally, the pump would be located downstream of the autosampler suction line intake, but the geometry of LS431 and the potential for high velocity flows [approximately 10,000 gallons per minute (gpm) for each lift station pump] limits where the pump can be mounted. A float switch, placed next to the pump, will trigger sample collection when stormwater flow is at a level high enough for proper pump operation. Care will need to be taken to place the float switch at the lowest level possible so that filtering will take place during as much discharge as possible, but high enough so the pump is adequately submerged per the manufacturer’s recommendation. Rigid polyvinyl chloride (PVC) pipe and flexible reinforced PVC tubing connected to the pump will transfer stormwater to the filter housing.

A flow totalizer capable of measuring flows between 0.5 and 20 gpm will be located downstream of the filter housing to measure the volume of water that has passed through the filter. Pressure gauges, placed immediately upstream and downstream of the filter housing, will measure pressure differential within the piping to monitor accumulation of solids on the filter bag's surface. As solids accumulate, stormwater flow through the filter will decrease and pressure will increase. The maximum recommended pressure differential across the filter is 15 pounds per square inch (psi). If this differential is exceeded, there is a risk of rupturing the filter bag. The pressure differential can increase quickly once a differential of 12 psi is reached, so collection of the bag may take place as soon as the differential reaches 12 psi. The bag may also be collected if the flow rate drops to zero prior to a differential pressure of 12 psi, as water is no longer being filtered. A pressure bypass valve may be installed prior to the filter housings which will allow bypass of the filters when the pressure exceeds 15 psi. Filtered stormwater will be directed back to the storm drain downstream of the submersible pump intake and the ISCO suction line and sensor via rigid PVC pipe and flexible reinforced PVC tubing attached to the outlet side of the filter housing.

2.3.3 SAMPLE COLLECTION METHODS

This section describes the methodology for collecting stormwater and stormwater solids samples from LS431.

2.3.3.1 Whole Water Samples

Whole water samples of stormwater will be collected at LS431. During each event, at least 16 aliquots of 500 milliliters (mL) each will be collected. The corresponding total volume of stormwater collected (8 liters) is planned to be sufficient to complete all chemical analyses required (see Section 2.3.4). The laboratory churn splitter holds a maximum of 15 liters, so efforts will be made not to exceed this amount of sample volume, if possible.

Necessary parameters for flow-weighted sampling include: predicted amount of precipitation, expected runoff volume, minimum volume required for analysis, minimum number of aliquots, sample aliquot size, and maximum bottle volume. Each program will be set up to meet the aliquot size and frequency requirements and the analytical volume requirements without filling the carboy with more than 15 liters of stormwater; however, the actual amount collected may be different than that planned due to the actual amount of precipitation, stormwater runoff, and equipment performance.

The sample collection process begins with precipitation forecast monitoring. The National Oceanic and Atmospheric Administration (NOAA) website offers a Quantitative Precipitation Forecast for 6-hour increments: http://www.wrh.noaa.gov/forecasts/graphical/sectors/sew.php#tabs. According to the sampling schedule described in Section 2.3.1, the sampling team will begin preparation for stormwater collection on the appropriate Monday of each month, including programming the autosampler based on the precipitation forecast. Next, the decontaminated 5-gallon carboy will be installed in the sample base and ice placed around the base of the carboy. The carboy will be kept on ice for the entire sampling event, and additional ice may need to be added to the ISCO base if the sampling event occurs during warm weather or over a long time period.

The sampling team will retrieve the carboy within 24 hours after the sampling event has concluded (i.e., the time the last aliquot was collected). At that point, the flow data from the autosampler will be downloaded for analysis. The carboy will be capped with a Teflon®-lined cap, labeled as described in Section 2.8, and submitted to the laboratory for the analyses required. The filled carboy will be heavy and fragile. To avoid damage, a garbage can or tote with handles will be used to move the carboy. During transit, the carboy will be surrounded with ice. Chain-of-custody forms will be filled out onsite (Section 2.8.4), and custody of the carboy will be transferred to ARI upon delivery. Using a churn splitter or similar device, laboratory staff will distribute proper volumes of homogenized stormwater to bottles for preservation or immediate analysis. Should there be an event where sample volume is insufficient to perform all of the requested analyses, Landau Associates will direct ARI in the priority of analysis (described further in Section 2.3.4). If, during the planning phase, it seems likely a sampling event will end on a weekend or during non-business hours, arrangements will be made with ARI staff to ensure that a technician is present to process the samples. Precipitation can be tracked online through the Seattle Boeing Field-King County International Airport rain gauge (identified as "KBFI") at http://www.wrh.noaa.gov/mesowest/getobext.php?wfo=sew&sid=KBFI&num=48&raw=0&dbn=m. The KBFI rain gauge data will be recorded to determine how much precipitation fell during the sampling period.

2.3.3.2 Filtered Solids Sample Collection

To collect filtered solids samples from LS431 stormwater, the in-line filtration system described in Section 2.3.2.2 will be activated. Prior to activation, new filter bags (pre-weighed and numbered by ARI for the filters used for analysis of PCBs) will be installed. The number(s) of the filter bag(s) used will be recorded in the field logbook.

Once sampling begins, the pressure gauge will be monitored approximately every 12 hours. If the pressure is near 15 psi, the system will be deactivated and the filter bags will be replaced. The flow volume through the first set of filter bags will be recorded in the field logbook. After filter bags have been removed, residual water in the bags will be allowed to gravity drain through the filter. Once drained, the filter bags will be placed in a sealable plastic bag and again labeled with the sample location name, sampler's name, date, and time. Collected samples will be double-bagged in Ziploc bags and stored in a cooler with ice. It is acceptable to use multiple bags for PCBs and for metals in one sampling event if the pressure differential approaches 15 psi or if flow through the filters has dropped below 1 gpm.

Additional bags to be analyzed for PCBs will be cataloged separately (separate label, sample name, and Ziploc bags). Additional bags for metals will be cataloged together (same sample name, can be combined in the same Ziploc bag).

2.3.4 LABORATORY ANALYSES

This section identifies the laboratory analyses for the whole water and solids samples collected at LS431. All analyses will be performed at ARI laboratory located in Tukwila, Washington, or other EPA-approved lab. A summary of the analyses to be performed is provided in Table 2.

2.3.4.1 Whole Water Samples

Whole water samples will be analyzed for PCBs using EPA Method 8082 and for TSS using Standard Method (SM) 2540. Whole water samples will also be analyzed for particle size distribution using the Ecology TAPE Method through December 2011, transitioning to a sampling schedule to be determined (in conjunction with EPA) starting January 2012. One possibility is to discontinue particle size distribution analysis after 2011. Boeing is in the process of determining the preferred method for particle size distribution from water samples at LS431. Samples from STST effluent were sent to UCLA for analysis using a Nicomp Particle Sizing Systems AccuSizer 780 optical particle sizer module, and we are awaiting results. Boeing has also made available a portable Sequoia LISST laser diffraction particle size analyzer for use at NBF, which can provide particle size distribution data in the field.

In addition, to provide information for the remedial investigation being conducted by Ecology at NBF and the GTSP, samples will be analyzed for total and dissolved metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc) using EPA Methods 200.8 and 7470, and semivolatile organic compounds (SVOCs) using EPA Method 8270. If insufficient sample is available for all analyses, the priority for analysis will be PCBs, TSS, total and dissolved metals, and SVOCs. The target reporting limits for each analysis are summarized in Table 3.

2.3.4.2 Filtered Solids Samples

Filtered solids will be analyzed for PCBs by EPA Method 8082. Grain-size distribution will no longer be analyzed from filtered solids samples, but will instead be analyzed from whole water samples. Also, based on past experience with the STST sampling, an adequate quantity of solids is not generated in the filter bag in order to perform PCB sampling for specific grain size fraction. Considering that the data collected from the STST monitoring showing that the CESF system effectively removes TSS and PCBs to below laboratory detection limits, analysis of PCBs by individual grain size fractions is determined to be not necessary. If sufficient sample is available, samples will also be analyzed for metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc) using EPA Methods 6010 and 7471 to provide information for the remedial investigation being conducted by Ecology at NBF and the GTSP.

For the PCB analyses, new filters will be weighed and numbered at ARI prior to sample collection, so that each sample can be matched to a unique, clean-filter weight. The used filter will be dried, weighed, and processed by ARI. For each filter, the entire filter (not including the hard plastic ring, but including whatever material was collected) will be extracted and the analytical results presented in units of total micrograms (µg) of PCBs. Knowing the full weight of the used dried filter (including collected material) and the pre-filtration weight, the estimated mass of PCBs per mass of total solids can be calculated. If multiple bags are to be analyzed for PCBs, ARI will process and report data for each bag, and the PCB concentrations will be calculated mathematically once the laboratory report is received. The target reporting limit for the PCB analysis of the filtered solids is summarized in Table 3.

For metals analyses, new filters do not need to be weighed and numbered prior to sample collection. At ARI, material will be scraped out of the filter bag and analyzed as a solids sample for metals. If multiple bags are to be analyzed for metals, ARI will scrape out material from the bags, homogenize, and run the analysis on the composite sample. The target reporting limit for the metals analysis of the filtered solids is summarized in Table 3.

2.3.5 EQUIPMENT DECONTAMINATION

Except for the glass carboys, the reusable equipment used to collect whole water and solids samples at LS431 is dedicated and will not be used at other locations; therefore, decontamination is not necessary for all equipment except the glass carboys. The laboratory decontaminates the sample carboys between sampling events.

2.4 LONG-TERM STORMWATER TREATMENT SYSTEM SAMPLING

Sampling at the LTST facility will consist of collecting whole water grab samples of the treatment facility influent and effluent and samples of the solids entrained in the influent and effluent. This section describes the sampling devices, sample collection and handling methods, frequency of sample collection, and laboratory analyses.

2.4.1 SAMPLING FREQUENCY

To evaluate the performance of the LTST facility, whole water samples will be collected from the treatment facility influent and effluent on a twice monthly basis for PCBs and TSS analyses through the end of 2011 and then monthly starting in 2012, as listed in Table 2. Whole water samples will be collected from sample ports on the two influent lines and one effluent line of the treatment system.

Whole water effluent samples will be collected on a twice-monthly basis by Clear Water for residual chitosan testing. This procedure is described in the Operation and Maintenance Manual (Appendix D of the 100% Design Report). One of the two monthly LTST influent and effluent sampling events will take place concurrent with the monthly LS431 sampling events described in Section 2.3.1. To monitor the LTST system performance under a variety of conditions, effort should be taken to collect whole water samples from the LTST system influent and effluent during both precipitation conditions and during base flow conditions. Reasonable efforts will be made to sample at various times during a storm (i.e., at the beginning of a storm and toward the end of a storm) and during various intensities of storms. Precipitation data will be recorded for conditions during sampling and up to 24 hours before sampling.

Filtered solids samples will be collected twice per month through the end of 2011 and monthly starting in 2012, and will be analyzed as described in Section 2.4.2.2. A summary of the sampling plan for the LTST facility is provided in Table 2.

2.4.1.1 Whole Water Sample Collection

Whole water samples will be collected from sample ports on the two influent lines and one effluent line of the treatment system. The specific sample collection procedures are as follows:

- Steps will be taken to attempt to sample the same parcel of water from both the influent and the effluent sides of the system. When the LTST system is operating continuously, the time of effluent sampling will be staggered from the time of influent sampling based on the estimated hydraulic retention time, calculated as effective storage volume divided by flow rate. During dry conditions (intermittent LTST operation), LTST system pumps will be manually turned on to transfer the parcel of water from the inlet weir tank to the storage tanks, then to the sand filter unit and effluent sampling location.
- Samples will be collected in laboratory-supplied sample bottles.
- Water will be allowed to purge from the sampling ports for a minimum of 20 seconds prior to collection of a sample. Purge water will be placed in the inlet weir tank.
- Samples will be collected by placing the appropriate sample bottles below the treatment system's sample ports and allowing the bottles to fill.
- Once a sample is collected, the bottle will be capped, sealed, and labeled.

The following items will be recorded at the time of sampling:

- Base flow conditions or precipitation event
- Approximate time rainfall began (either from KBFI rain gauge data or from field observation)
- Date and time of sampling
- How the hydraulic retention time in the system was calculated, or otherwise how the same parcel of water was sampled from the influent and effluent
- If the sampling was concurrent with a monthly LS431 sampling event
- Name of the sampler(s)

- Turbidity of influent and effluent (if sampler has access to LTST control unit) at time of sampling
- Unusual circumstances that may affect the sample results.

2.4.1.2 Filtered Solids Sample Collection

To collect solids samples from the treatment facility influent and effluent, filtration systems will be installed on each influent pipeline (between MH130A and the CESF system and between the Lift Station inlet vault and the CESF system) and on the effluent pipeline (between the CESF system and discharge to LS431). The three filter systems are located on the LTST system pipelines, as shown on the LTST system drawings (Appendix A of the 100% Design Report). A submersible pump located in MH130A will pump influent water from the north lateral through an underground pipe that will surface near the LTST system. This filtration system will filter solids from the preferentially-treated north lateral stormwater. The other filtration systems are also adjacent to the LTST system. Submersible pumps located in the Lift Station inlet vault will pump influent water from the rest of the NBF storm drain system (up to the design flow rate of the LTST facility) through above-ground pipe to the LTST system. Treated (effluent) water is pumped through above-ground pipe to the discharge point in LS431. A portion of each of the three streams will pass through a filter bag where solids will be captured.

At each filter system, one FSI model CBFP-11 carbon steel filter housing will be equipped with a 16-inch-long, 7-inch-diameter, pre-weighed and pre-numbered 1 μm polypropylene felt filter bag with a Polyloc® seal (to prevent bypass) to collect influent or effluent solids. A flow totalizer will be placed downstream of each filter and will be used to measure the total volume of stormwater flowing through the filter bag. Filtered water from influent sampling will then be conveyed to overflow pipe that leads back to the Lift Station inlet vault (OWS421), while filtered water from effluent sampling will rejoin the discharge flow prior to discharge to LS431.

The amount of filtration time for each filter bag will be determined in the field, as the amount of solids in the influent and effluent will vary. The flow rates at each will be checked no less than twice per month. If the filter bag becomes clogged, the flow will slow or stop and a sample will be collected. Each filter will be removed following successful completion of filtration and handled according to the procedures in Section 2.8.

The specific sampling procedure at each filtration system (influent and effluent) is as follows:
Use only a clean, new filter that has been pre-weighed and numbered by the laboratory. Once a filter bag is removed, the filter will be placed in a clean plastic bag, sealed, and labeled. The following items will be recorded at the time of sampling:

- Date and time filtration began

- Date and time filtration ended
- The lab-determined number and weight of the filter used
- Reading from the flow totalizer at start of filtering
- Reading from the flow totalizer at end of filtering
- Name of the sampler(s)
- Unusual circumstances that may affect the sample results.

2.4.2 LABORATORY ANALYSES

This section identifies the laboratory analyses for the stormwater and solids samples collected at the LTST system to evaluate the performance of the facility. All analyses, except the residual chitosan, will be performed at ARI laboratory. A summary of the analyses to be performed is provided in Table 2.

2.4.2.1 Whole Water Samples

Whole water samples of the treatment facility influent and effluent will be analyzed at ARI for PCBs using EPA Method 8082 and for TSS using Method SM2540. The target reporting limits for each analysis are summarized in Table 3. Discrete whole water samples of the effluent will also be analyzed for residual chitosan by Clear Water.

2.4.2.2 Filtered Solids Samples

Each filtered solids sample collected from the LTST facility influent and effluent will be analyzed for PCBs. The target reporting limits for the PCBs analyses are summarized in Table 3. Filtered solids will be analyzed for PCBs by EPA Method 8082. For the PCBs analyses, new filters will be weighed and numbered at ARI prior to sample collection, so that each sample can be matched to a unique, clean-filter weight. The used filter will be dried, weighed, and processed by ARI. For each filter, the entire filter (not including the hard plastic ring, but including whatever material was collected) will be extracted and the analytical results presented in units of total µg of PCBs. Knowing the full weight of the used dried filter (including collected material) and the pre-filtration weight, the estimated mass of PCBs per mass of total solids can be calculated.

2.4.3 EQUIPMENT DECONTAMINATION

Only dedicated sampling ports, dedicated pumps, and clean, new bottles and filters are planned to be used for sample collection. However, in the event that any equipment needs to be reused, the equipment will be cleaned by scrubbing all surfaces that will come into contact with the sample with brushes using an Alconox solution, rinsing and scrubbing with clean tap water, and rinsing a final time with distilled or de-ionized water to remove tap water impurities. Decontamination, if required, will be conducted between collection of each sample.

2.5 SEDIMENT TRAPS

The sediment trap monitoring program that began in 2005 at the NBF site will be continued during operation of the LTST facility to evaluate stormwater quality from the individual NBF lateral storm drains prior to combining at the Lift Station inlet vault and treatment at the LTST facility. This data will provide additional characterization of stormwater quality, and will aid in future remedial action decisions. Sediment traps will continue to be deployed at the locations shown on Figure 5 (except for SL4-T5A, which will be moved to the "Buried Manhole" or other upstream location). The sediment trap bottles were last collected and reinstalled on April 5, 2011, and sediment trap solids samples will be collected again in spring 2011. A summary of the sampling plan for the sediment traps is provided in Table 2. Sediment trap sampling will continue indefinitely until such time that additional data collection is no longer needed to support source control efforts. Sediment trap data will be evaluated and may result in additional sampling and analysis efforts to support source control activities.

2.5.1 SAMPLE COLLECTION

Each sediment trap will consist of two stainless-steel brackets and housings that each holds a Teflon® sample container. Once the containers are securely placed on the bracket, the container lids will be removed and placed in a plastic sealable bag and labeled with the sample location. After the desired sample duration has elapsed, the lids will be placed back on the containers and the containers removed. The containers will be labeled as described in Section 2.8.1. Samples will be stored on ice in a cooler for transportation to ARI laboratory. New laboratory-cleaned containers will be placed in the brackets for collection of the next round of samples.

2.5.2 LABORATORY ANALYSIS

Analysis of the sediment trap solids samples will include PCBs using EPA Method 8082; semivolatile organic compounds (SVOCs) using Puget Sound Dredged Disposal Analysis (PSDDA) SVOCS SW8270D; total metals (arsenic, copper, lead, mercury, and zinc) using Methods 6010 and 7471; diesel-range and motor oil-range petroleum hydrocarbons using Ecology Method NWTPH-Dx; total organic carbons using the method described in Plumb (1981), and grain size. Depending on the quantity of solids collected, the laboratory may not be able to analyze all parameters, in which case, the analysis of parameters will be prioritized in the order listed above. The target reporting limits for each analysis are summarized in Table 3; however, depending on the quantity of solids collected and possible interferences, actual reporting limits may be higher than those listed.

Prior to field mobilization, all sampling equipment and utensils will be thoroughly decontaminated. The ARI laboratory will be responsible for decontamination of the Teflon® sample container.

2.6 WEIR TANK, STORAGE TANK, AND SANDFILTER MEDIA SAMPLING

Grab samples of the residual solids at the bottom of the LTST facility inlet weir tank, backflush settling tank, and storage tanks will be collected to determine appropriate disposal of the solids. The solids level in the inlet weir tank, each storage tank, and the backflush settling tank will be inspected at least once per month. For the inlet weir tank and the storage tanks, if the solids level at the bottom of the tank is greater than 12 inches, a sample of the solids will be collected for waste profiling purposes and the solids will be cleaned out from the tank. The flow rate through the backflush settling tank will be low enough that re-entrainment of solids is less likely than at the other tanks, and a deeper blanket of solids could accumulate without negative effects. Additionally, a deeper blanket of solids may allow for sludge thickening, which would limit the amount of liquid that would need to be removed and disposed of during tank cleanout. Therefore, the depth of solids in the backflush settling tank may be allowed to reach up to 24 inches prior to waste profiling and cleanout.

Monitoring of accumulated solids will be performed with a Sludge Judge® or similar device inserted from the top of the tank to the tank floor. The device collects a sample that can be retrieved and visually inspected. The thickness of accumulated solids in the sampler is observed and recorded. Three or more readings, spread approximately equally along the length of the tank (for the weir tanks, the readings will be taken between the weir and the inlet end of the tank), will be averaged and used to determine if the solids level exceeds the aforementioned depths and requires solids testing and tank cleanout.

The allowable depth of sludge blanket in each tank may be adjusted if monitoring suggests that the optimum sludge blanket depth is greater or less than the aforementioned depths. For example, if turbidity monitoring shows enhanced flocculation at the Inlet Weir Tank due a depth of solids greater than 12 inches, the depth at which cleanout is triggered may be modified.

Tank cleanout will consist of pumping as much water as possible from the tank for treatment in the LTST system, then vactor removal of the solids and liquid that remains. The vactor truck will deposit the sludge at the onsite Sweeper Decant Station for dewatering. The liquid will be batch treated at the Decant Station and (when it meets water quality limits) discharged to the King County sewer under an

Industrial Wastewater Permit. The solids will be disposed of off site, using the waste characterization laboratory data provided by tank sampling as described in Section 2.6.1.1.

Disposal characterization sampling will also be conducted for the sand media in the three sand filter units. It is expected that sand filter media will last for approximately 20 million gallons before needing to be replaced. It is possible that, if reduced sand filtration performance is observed during the course of operation, the used sand media would be replaced earlier than expected. A composite sample of the used sand filter media (three or more grab samples) will be collected prior to its disposal into the waste solids bins associated with the Sweeper Decant Station. The spent media will be disposed of offsite, using the waste characterization laboratory data provided by vessel sampling as described in Section 2.6.1.2. Sampling of spent sand filter media for waste characterization will be conducted for the first media replacement, and this data will be used for all subsequent media disposal unless there is reason to believe that contaminant concentrations at the LTST influent have changed significantly (outside the range for influent treated with first batch of sand filter media), in which case another round of waste characterization sampling will be conducted.

2.6.1 SAMPLE COLLECTION

This section describes the methodology for collecting solids samples from the LTST weir and storage tanks, and from the sand filter units.

2.6.1.1 Weir and Storage Tank Solids

If tank solids are to be removed, a minimum of three grab samples will be collected from equally-spaced discrete locations (similar to procedure for checking sludge thickness described above) at the bottom of the tank, using clean laboratory-supplied glass soil sampling jars affixed to the end of a telescoping sampling pole. Water will be decanted from each jar, to the extent possible, and the solids from each jar will be combined and homogenized in a clean stainless-steel bowl using a clean stainless-steel spoon, placed into a separate sample jar, labeled, and stored in a cooler on ice. The sampler will remove material greater than about ¼-inch diameter prior to placing the soil in the sample container. A new clean sample jar will be affixed to the telescoping sample pole at each new location.

2.6.1.2 Sand Filter Media

When sand filter media is to be removed and replaced, a composite sample of the media, composed of a minimum of three grab samples from each individual sand filter vessel to be emptied, will be collected using a stainless steel spoon. Locations of the grab samples will be taken from different vertical positions in the vessel so as to result in a representative sample of spent media. All grab samples

(12 or more, assuming media from all four vessels in a unit is being removed) will be homogenized in a clean stainless-steel bowl using a clean stainless-steel spoon, placed into a laboratory-supplied soil sample jars, labeled, and stored in a cooler on ice.

2.6.2 LABORATORY ANALYSIS

Each solids sample will be analyzed for PCBs using EPA Method 8082; SVOCs using EPA Method 8270D (full scan); metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver) using EPA Method 1311 (the toxicity characteristic leaching procedure), EPA Method 6010 for metals except mercury, and EPA Method 7471 for mercury; diesel-range and motor oil-range petroleum hydrocarbons using Ecology Method NWTPH-Dx; and gasoline-range petroleum hydrocarbons using Ecology Method NWTPH-Gx.

2.6.3 EQUIPMENT DECONTAMINATION

All non-disposable sampling equipment (e.g., stainless-steel bowls and spoons), or other equipment used to collect the solids samples, will be decontaminated as follows:

- Potable water rinse
- Alconox/Liquinox detergent wash
- Potable water rinse
- Deionized (DI) or distilled water rinse
- Air dry.

2.7 RE-ROUTED KING COUNTY STORMWATER

In order to determine if the re-routed stormwater from King County is contributing to an inability of the LTST system to meet the EPA interim goals, flow rate monitoring and water quality sampling will be performed on this re-routed storm drain line.

Flow rate monitoring will take place at the new wet vault near the LTST, as discussed in the 100% Design Report, using a weir and pressure transducer similar to the existing setup at MH130B. To trigger flow-weighted whole water composite sampling, it is anticipated that either this flow data will be used, or flow would additionally be monitored with a flow sensor similar to the one used at LS431 at a separate location upstream. This location will be somewhere between the wet vault and the starting point of the new re-routed line, which is referred to as the "Buried Manhole", and is shown on Figure 5. The final sampling location will be determined based on site constraints and feasibility. Filtered solids collection will take place at the same location as whole water sampling.

Because there is interest to compare data from King County re-routed stormwater to the overall stormwater discharge at LS431, both whole water composite sampling and filtered solids sampling will be conducted at the to-be-determined location along the re-routed King County storm drain line. The same sampling frequency and sample analysis will be followed as listed above in Section 2.3 for LS431, with some exceptions:

- Only one filter housing will be used (not two in parallel).
- For filtered solids, only PCBs will be analyzed (not metals).
- For whole water, only PCBs, TSS, and particle size distribution will be analyzed (not metals or SVOCs).

2.8 SAMPLE LABELING AND HANDLING

This section describes the sample labeling and handling procedures that will be used during the stormwater and stormwater solids sampling that will be conducted while the LTST facility is operating.

2.8.1 SAMPLE IDENTIFICATION AND LABELS

Sample container labels will be completed immediately before or immediately following sample collection. Container labels will include the project name (NBF); the project number (0025082.311 for 2011 samples and 0025082.312 for 2012 samples); the sample ID; the initials of the person collecting the sample; the date and time of collection; and the analysis required. Date and time of collection for LS431 and re-routed King County whole water samples will coincide with the time the last aliquot was collected, not the date and time that field personnel removed the carboy from the ISCO sampler. All samples collected during the investigation will be labeled clearly and legibly. Sample labels will be self-adhering, waterproof material. An indelible pen will be used to fill out each label.

2.8.2 SAMPLE CONTAINERS, PRESERVATION, AND STORAGE

Samples submitted to the analytical laboratory for analysis will be collected in the appropriate sample container provided by the analytical laboratory appropriate for the matrix being analyzed and the requested analytes with the following exceptions. Pre-purchased sediment trap containers and 5-gallon glass carboys will be reused at each sediment trap location and at LS431/Re-routed King County location, respectively. These containers will be cleaned by ARI laboratory between uses. New filters will be purchased for each filtered solids sample. Each filter will be pre-weighed and numbered by ARI prior to use, with the exception of the filter bags to be analyzed for metals at LS431. All samples will be preserved by cooling to a temperature of 6° Celsius (C) and as required by the analytical method. Maximum holding and extraction times until analysis will be strictly adhered to by field personnel and the analytical laboratory. Sample containers, preservatives, and holding times for each chemical analysis to be performed are presented in Table 4.

2.8.3 SAMPLE PACKAGING AND SHIPPING

The transportation and handling of samples will be accomplished in a manner that not only protects the integrity of the sample, but also prevents any detrimental effects due to the possible hazardous nature of samples. Regulations for packing, marking, labeling, and shipping of hazardous materials are promulgated by the U.S. Department of Transportation in the Code of Federal Regulations (CFR), 49 CFR 173.6 and 173.24.

Prior to transportation to the laboratory, samples will be placed on double-bagged ice in coolers following collection, with the exception of 5-gallon carboys, which will be surrounded by loose ice in a rigid plastic garbage can or tote. At the end of the day, samples sent to the analytical laboratory will be inventoried. Each cooler will be secured with signed custody seals.

Samples will be transported to the laboratory within 24 hours of sample collection with the following exception. If multiple rounds of filter bags are used for a LS431/Re-routed King County sampling event due to accumulation of solids and pressure differentials approaching 15 psi or clogging of filters, field personnel will keep the collected filter bags in plastic bags and on ice in a cooler until the sampling event has concluded. All filter bags from a sampling event will be submitted to the laboratory at the same time. Coolers may be transported to the laboratory by the laboratory's courier or delivered to the laboratory by field sampling personnel.

2.8.4 SAMPLE CUSTODY

The primary objective of sample custody is to create an accurate, written record that can be used to trace the possession and handling of samples so that their quality and integrity can be maintained from sample collection until completion of all required analyses. Adequate sample custody will be achieved by means of approved field and analytical documentation. Such documentation includes the chain-of-custody record, which is initially completed by the sampler and is, thereafter, signed by those individuals who accept custody of the sample.

3.0 QUALITY ASSURANCE PROJECT PLAN

This QAPP presents the QA and QC plan for the field sampling and laboratory analyses associated with the NBF LTST removal action. The purpose of this plan is to ensure that all necessary actions or protocols are implemented to acquire data of the type and quality needed to meet the project goals.

This QAPP was prepared in accordance with EPA Requirements for Quality Assurance Project Plans (QA/R-5; EPA/240/B-01/003, March 2001a) and the following EPA guidance documents: Guidance for Quality Assurance Project Plans (QA/G-5; EPA/240/R-02/009, December 2002) and Quality Assurance/Quality Control Guidance for Removal Activities (EPA/540/G-90/004, April 1990).

3.1 QUALITY ASSURANCE OBJECTIVES

The QA objectives for this project are to develop and implement procedures that will ensure collection of representative data of known, acceptable, and defensible quality. The data quality parameters used to assess the acceptability of the data are precision, accuracy, representativeness, comparability, and completeness. These parameters are discussed in the following sections.

3.1.1 DECISION QUALITY OBJECTIVES

The decision quality objectives define the type, quality, and quantity of data necessary to support project decisions. As presented in the ASAOC, the project goal is to reduce PCB concentrations in stormwater discharging to the Slip 4 EAA of the LDW Superfund site to below 0.030 µg/L and the amount of storm drain solids discharged to below 100 ppb dry weight total PCBs. The sampling objectives are described in Section 2.1. To support these objectives, samples of stormwater and stormwater solids must be representative of conditions during a variety of stormwater flows, the results must be comparable to the long-term interim goals, and the data must be complete to ensure sufficient data is collected to support project decisions. Representativeness, comparability, and completeness are discussed further below.

3.1.1.1 Representativeness

Representativeness expresses the degree to which data accurately and precisely represent an actual condition or characteristic of a population. Representativeness can be evaluated using replicate samples, representative sampling locations and conditions, and blanks. The FSP (Section 2.0) specifies the types and number of samples to collect and the appropriate sampling locations. As described in the FSP, stormwater and stormwater solids samples will be collected from the storm drain system prior to and following treatment. In some cases, samples will be collected over the course of multiple days during varying precipitation conditions, other samples will be instantaneous grab samples collected twice a month during various precipitation conditions, and other information will be collected on a continuous basis. This range of sampling frequency will provide data that is representative of a variety of stormwater flow conditions at the site. Additionally, to determine that the analytical results are representative of the sampled item and not influenced by cross-contamination, method blanks will be analyzed with each analysis as described in Section 3.4.5.7.

3.1.1.2 Comparability

Comparability expresses the confidence with which one data set can be evaluated in relation to another data set. For this work, comparability of data will be established through the use of consistent sampling procedures and the use of EPA-approved analytical methods with target reporting limits that can meet the compliance criteria set for this project. Analytical methods to be used for analysis of stormwater and stormwater solids samples are discussed in Section 3.4.4.

3.1.1.3 Completeness

Completeness is a measure of the proportion of data obtained from the requested analytical method that is determined to be valid. It is calculated as the number of valid data points divided by the total number of data points requested. The QA objective for completeness during this project will be 95 percent. Completeness will be routinely determined and compared to this control criterion.

3.2 MEASUREMENT QUALITY OBJECTIVES

The measurement quality objectives (MQOs) for the project specify how good the data must be in order to meet the objectives of the project and are based on data precision, accuracy, bias, and sensitivity, as described below.

3.2.1 PRECISION

Precision measures the reproducibility of measurements under a given set of conditions. Specifically, it is a quantitative measure of the variability of a group of measurements compared to their average values.

Analytical precision can be measured through laboratory control samples and duplicates. Laboratory control samples and duplicates will be collected as described in Sections 3.4.5.1 and 3.4.5.2. Laboratory precision will be evaluated against quantitative relative percent difference (RPD) performance criteria provided by the laboratory.

Precision measurements can be affected by the nearness of a chemical concentration to the method detection limit, where the percent error (expressed as RPD) increases. The equation used to

$$RPD = \left| \frac{D_1 - D_2}{(D_1 + D_2)/2} \right| x\,100$$

express precision is as follows:

where: D1 = first sample value

D2 = second sample value (duplicate).

3.2.2 ACCURACY

Accuracy is an expression of the degree to which a measured or computed value represents the true value. Field accuracy is controlled by adherence to sample collection procedures as outlined in the FSP (Section 2.0).

Analytical accuracy may be assessed by analyzing "spiked" samples with known standards [surrogates, laboratory control samples, and/or matrix spike MS)] and measuring the percent recovery. Laboratory control samples and duplicates will be collected as described in Sections 3.4.5.1 and 3.4.5.2.

Accuracy can be expressed as a percentage of the true or reference value, or as a percent recovery in those analyses where reference materials are not available and spiked samples are analyzed. The equation used to express accuracy is as follows:

$$\begin{matrix} \textit{Percent} \\ \textit{Recovery} \end{matrix} = \frac{\textit{(Spiked Sample Result - Unspiked Sample Result)}}{\textit{Amount of Spike Added}} \; x \; 100$$

Control limits for percent recovery for water and solid samples will be laboratory acceptance limits generated according to EPA guidelines.

3.2.3 BIAS

Bias is the systematic or persistent distortion of a measured process that causes errors in one direction. Bias of the laboratory results will be evaluated based on analysis of method blanks as described in Section 3.4.5.7.

3.2.4 SENSITIVITY

Sensitivity is the ability to discern the difference between very small amounts of a substance. For the purposes of this project, sensitivity is the lowest concentration that can be accurately detected by the analytical method. The analytical method will be considered sufficiently sensitive if the reporting limits are below the compliance criteria discussed in Section 1.4. Proposed method and target reporting limits are discussed in Section 3.4.4.

3.3 SPECIAL TRAINING/CERTIFICATION

All personnel performing sampling activities onsite will have completed formal 40-hour HAZWOPER health and safety training, in compliance with 29 CFR 1910.120 and Washington Administrative Code (WAC) Chapter 296 (certificates of successful completion of training will be maintained in personnel health and safety files), and will verify on-the-job training for those activities they are assigned to perform. At least one member of each field team and the designated site safety officer will be trained in cardiopulmonary resuscitation (CPR) and first aid.

The laboratory performing the analysis of the samples will be ARI or other EPA-approved lab. ARI is certified by the State of Washington and the National Environmental Lab Accreditation Conference (NELAC) to perform the methods listed in this QAPP. This laboratory is not in the Contract Laboratory Program (CLP), but follows methods and QA/QC procedures that have been submitted and approved by EPA. ARI has a documented Quality Assurance Program that complies with ANSI/ASQC E-4 1994, "*Specifications and Guidelines for Quality Systems for Environmental Data Collection and Environmental Technology Programs*," (American National Standard, January 5, 1995) and "EPA Requirements for Quality Management Plans (QA/R-2)" (EPA/240/B-01-002, March 2001b).

Work in confined spaces (WAC 296-62-Part M) may be necessary to maintain sampling equipment at LS431. Entering confined spaces requires specialized training and procedures outlined by the Occupational Safety and Health Administration (OSHA). OSHA issued a general industry standard (29 CFR 1910.146; the standard) to require protection for employees who enter permit-required confined spaces. The corresponding Labor and Industries [Washington Industrial Safety and Health Act (WISHA)] regulation is found at Chapter 296-809 WAC. All personnel entering a confined space will be trained and certified in accordance with OSHA and WISHA. Confined space entry will also be conducted in accordance with Boeing requirements.

3.3.1 DOCUMENTS AND RECORDS

This section describes the production, distribution, and storage of documents and records associated with sampling activities related to the LTST facility.

3.3.2 DOCUMENT DISTRIBUTION

Prior to beginning any field activities, field staff will receive and have a chance to review all project documents pertinent to the field activities including the SAP and a Health and Safety Plan

(HASP). Project managers will meet with field staff prior to field activities to review the SAP. The HASP will be reviewed by all staff collecting samples.

3.3.3 FIELD DOCUMENTATION

All field equipment (e.g., automated stormwater samplers) will have reference manuals that will be kept available during sampling or maintenance activities. In addition, equipment that requires calibration will be accompanied by a calibration logbook. Field staff will record the calibration process in the logbook every time a calibration is performed.

A complete record of all field activities will be maintained for 10 years after notification by EPA of completion of the work under the ASAOC. Documentation necessary to meet QA objectives for this project include daily field notes, sampling forms, and sample chain-of-custody forms. All original documentation will be kept in the Landau Associates' project files. The documentation and other project records will be safeguarded to prevent loss, damage, or alteration.

If an error is made on a document, corrections will be made by drawing a single line through the error and entering the correct information. The erroneous information will not be obliterated. Corrections will be initialed and dated, and, if necessary, a footnote explaining the correction will be added. Errors will be corrected by the person who made the entry, whenever possible. Documentation will include field notes and associated documents.

The field notes will provide a description of all sampling activities, sampling personnel, weather conditions, and a record of all modifications to the procedures and plans identified in the SAP. The field notes are intended to provide sufficient data and observations to enable participants to reconstruct events that occurred during the sampling period.

Field notes will be supplemented by sample collection forms completed by field staff. Sample possession and handling will also be documented with chain-of-custody records so that the samples are traceable from the time of sample collection to arrival at the laboratory and to sample analysis. Sample handling and chain-of-custody procedures are described in Section 2.8.

3.3.4 ANALYTICAL DATA RECORDS

Analytical data reports consisting of a case narrative, field sample results, method blank, laboratory control sample, surrogate recovery, and MS results will be provided by the laboratory. The reports will be submitted in hard copy and electronically as PDF files. All of the analytical data, including the laboratory QC results, will be submitted as an electronic data deliverable (EDD) in the laboratory's standard Excel format.

3.3.5 STORAGE

Documents and records associated with the project will be stored in electronic form in project files on Landau Associates' servers, and in hard copy in Landau Associates' files for the duration of the project. After completion of the project, hard copy files will be stored at Iron Mountain storage facility for at least 10 years after notification by EPA of completion of the ASAOC requirements.

3.4 DATA GENERATION AND ACQUISITION

This section provides an overview of the data collecting and handling procedures that will be implemented to ensure the integrity of the samples and quality of the resulting data. More details about these processes are included in the FSP (Section 2.0).

3.4.1 SAMPLING PROCESS DESIGN

The sampling design includes collection of whole water stormwater samples and filtered stormwater solids samples at LS431 to monitor compliance with the LTST interim goals identified in Section 1.4, and whole water and filtered solids samples from the LTST facility influent and effluent to evaluate the effectiveness of the treatment facility in removing PCBs and solids from the stormwater. These samples will be collected during varying precipitation conditions to evaluate the effectiveness of the LTST facility under a variety of storm flows. Solids samples from sediment traps located throughout the NBF storm drain system will provide data to continue stormwater characterization from individual storm drain laterals and from offsite flows. Solids samples from weir tanks, storage tanks, and sand filter vessels will provide data to be used for waste characterization and disposal procedures. Whole water and filtered solids samples from the re-routed King County stormwater line will provide data to be used to determine whether contaminant concentrations in King County water are adversely affecting the ability of the LTST system to meet interim goals at LS431, and to influence decisions on whether to re-route the water away from the LTST system.

3.4.2 SAMPLING METHODS

Whole water samples from LS431 will be collected using an automated sampler. This automated sampler will allow collection of flow-weighted composite whole water samples by collecting aliquots of the stormwater more frequently at high flow rates and less frequently at low flow rates. The flow-weighted composite samples will be more representative of stormwater quality discharging to Slip 4 of the LDW than discrete samples. Solids will be collected from LS431 discharge and the LTST facility influent and effluent using filtration systems. The use of these systems increases the opportunity for collecting adequate solids sample volumes to perform the desired analyses.

Samples submitted to the analytical laboratory for analysis will be collected in the appropriate sample containers. Sample containers for the LTST facility whole water influent and effluent grab samples, and the weir tank, storage tank, and sand filter solid samples, will be provided by the laboratory. Whole water samples collected at LS431 and from the re-routed King County line will be submitted to the analytical laboratory in a pre-purchased 5-gallon glass carboy that is used in conjunction with the whole water automated sampling device. Carboys will be cleaned between sampling uses by the analytical laboratory. Sediment trap solids will be submitted to the laboratory in the Teflon® containers used to trap sediment. The Teflon® containers will be cleaned between sampling uses by the analytical laboratory. Filtered solids samples will be submitted to the laboratory in the filter placed inside a sealable plastic bag. New filters will be used for each sample and will be pre-weighed and numbered by ARI prior to use.

Any non-dedicated sampling equipment that will be reused will be decontaminated to avoid cross contamination between samples. Decontamination procedures are described in the FSP (Section 2.0)

3.4.3 SAMPLE HANDLING AND CUSTODY

The transportation and handling of samples will be accomplished in a manner that not only protects the integrity of the sample, but also prevents any detrimental effects due to accidental release of samples. Samples will be logged on a chain-of-custody form and will be kept on ice until delivery to the analytical laboratory. With the exception of the 5-gallon carboys, samples will be kept in coolers until delivery to the analytical laboratory. The chain-of-custody will accompany each shipment of samples to the laboratory. The storage temperatures and maximum holding times for physical/chemical analyses, presented in Table 4, will be strictly adhered to during each sampling event. Procedures for sample handling and transportation are described in greater detail in the FSP (Section 2.0).

3.4.4 ANALYTICAL METHODS

The results for the stormwater and solids sampling will be compared to the LTST interim goals [0.030 µg/L PCBs in stormwater, 100 micrograms per kilogram (µg/kg) PCBs in solids]; therefore, the methods used to analyze the samples must be able to detect analyte concentrations equal to or less than the LTST interim goals. Laboratory methods and target reporting limits for the analysis of stormwater and stormwater solids that meet that meet these criteria are summarized in Table 3.

3.4.5 QUALITY CONTROL

Analytical laboratory control samples will be collected and/or analyzed to evaluate data precision, accuracy, representativeness, completeness, and comparability of the analytical results. A summary of the quality control samples and the frequency at which they will be collected and/or analyzed is described in the following subsections.

3.4.5.1 Laboratory Control Samples

Laboratory control samples will be performed on whole water samples. A minimum of one laboratory control sample per 20 samples, not including QC samples, or one laboratory control sample per sample batch if fewer than 20 samples are obtained, will be analyzed for PCBs.

3.4.5.2 Laboratory Duplicates

Laboratory duplicates will be performed on whole water samples. A minimum of one laboratory duplicate per 20 samples, not including QC samples, or one laboratory duplicate sample per batch of samples if fewer than 20 samples are obtained, will be analyzed for PCBs. Laboratory duplicates will be performed using project samples. These analyses will be performed to provide information on the precision of chemical analyses. The laboratory duplicate will follow EPA guidance in the method.

3.4.5.3 Blind Field Duplicate

No blind field duplicate samples are planned.

3.4.5.4 Field Equipment Rinsate Blanks

Field equipment rinsate blanks consist of deionized water passed over decontaminated sampling equipment and transferred to sample containers for analysis at the laboratory. Except for the residual solids sampling at the weir and storage tanks and from the sand filter vessels, all stormwater and solids sampling will be conducted using disposable and/or dedicated equipment, thereby eliminating potential cross contamination between samples or sampling events via sample equipment. No field equipment rinsate blank samples will be collected. Because the residual solids samples are being collected for disposal characterization and are not being collected to meet the sampling objectives, no equipment rinsate blanks will be collected in conjunction with these samples.

3.4.5.5 Laboratory Matrix Spike

No laboratory MS samples are planned.

3.4.5.6 Laboratory Matrix Spike Duplicate

No laboratory matrix spike duplicate (MSD) samples are planned.

3.4.5.7 Laboratory Method Blanks

A minimum of 1 laboratory method blank per 20 samples, 1 every 12 hours, or 1 per batch of samples analyzed (if fewer than 20 samples are analyzed) will be analyzed for all parameters (except particle size and total solids) to assess possible laboratory contamination. Dilution water will be used whenever possible. Method blanks will contain all reagents used for analysis. The generation and analysis of additional method, reagent, and glassware blanks may be necessary to verify that laboratory procedures do not contaminate samples.

3.4.6 INSTRUMENT/EQUIPMENT/CONSUMABLES

All field equipment used for this project will be maintained and operated by Boeing or their consultant. Maintenance and calibration of the equipment is discussed in the FSP (Section 2.0). The analytical laboratory project manager is responsible for maintaining laboratory instruments in proper working order including routine maintenance and calibration, and training of personnel in maintenance and calibration procedures. Laboratory instruments will be properly calibrated with appropriate check standards and calibration blanks for each parameter before beginning each analysis. Instrument performance check standards, where required, and calibration blank results will be recorded in a laboratory logbook dedicated to each instrument. At a minimum, the preventive maintenance schedules contained in the EPA methods and in the equipment manufacturer's instructions will be followed.

3.4.7 DATA MANAGEMENT

All laboratory analytical results, including QC data, will be submitted in hard copy and electronically. Electronic format will include comma separated value (CSV) files that will be downloaded directly to an Access database. Following validation of the data, any qualifiers will be added to the database.

Hard copies of the laboratory chemical analytical reports will include the following:

- Case narrative, including adherence to prescribed protocols, nonconformity events, corrective measures, and/or data deficiencies
- Sample analytical results
- Surrogate recoveries
- MS/MSD spike duplicate results
- Blank spike/blank spike duplicate results
- Laboratory duplicates
- Blank results

- Sample receipt forms (including signed, original chain-of-custody records)
- Analytical responsibility.

Until such time that EPA approves of alternate reporting requirements, Boeing will continue to prepare monthly progress reports and submit those reports to EPA by the fifth day of the following month (or the first subsequent work day if the fifth day of the month falls on a weekend or holiday). Monthly progress reports will continue to include information related to stormwater treatment system operation (e.g., total gallons of stormwater treated, rainfall data, any significant operational problems or system shutdowns) and will contain summary data tables of all validated stormwater analytical testing results that were received from the laboratory by the 24th of the month. Results of the Stage 2A data validation (described below in Section 3.6) will be documented in a technical memorandum, which will include a disk with electronic copies of chain of custody forms and laboratory data packages, and submitted to EPA with project monthly reports.

3.5 ASSESSMENT AND OVERSIGHT

Assessments used during implementation of the project will include daily communication and updates during field work and data quality review by the Landau Associates' project and task managers. Response actions to assess issues will be coordinated between these managers; the field manager; the project managers for Boeing and EPA; and involved subcontractors, as appropriate.

Although not planned, the EPA QA officer or designee may conduct an audit of the field activities for this project. The auditor will have the authority to stop work upon finding a significant condition that would adversely affect the quality and usability of the data. The Landau Associates' project manager will then have the responsibility for initiating and implementing response actions to address these deficiencies identified by the site audit. Once the response action(s) have been implemented, the EPA QA officer or designee may perform a follow-up audit.

If a QA/QC audit detects unacceptable conditions or data, the Landau Associates' project manager will be responsible for developing and initiating corrective action. Corrective action may include the following:

- Reanalyzing the samples, if holding times can be met
- Resampling and analyzing
- Evaluating and amending sampling and analytical procedures
- Accepting data and acknowledging the level of uncertainty or inaccuracy by flagging the data.

All corrective actions will be documented in writing and will be signed by the project manager and implementing manager.

3.6 DATA VALIDATION AND USABILITY

All stormwater and solids data will be verified and validated to determine the results are acceptable and meet the quality objectives described in Section 3.1 Prior to submitting a laboratory report, the laboratory will verify that all the data are consistent, correct, and complete, with no errors or omissions.

A Stage 2A validation, as defined in EPA's *Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use* (EPA 2009), will be conducted for all of the data. The Stage 2A validation of the data will be performed by Landau Associates following the guidelines in the appropriate sections of the EPA *Contract Laboratory Program National Functional Guidelines for Organic and Inorganic Data Review* (EPA 1999 and 2004) and will include evaluations of the following:

- Chain-of-custody records
- Sample conditions upon receipt at the laboratory (including preservation, pH, and temperature
- Holding times
- Laboratory method blanks
- Surrogate recoveries
- Laboratory MSs and MSDs
- Blank spikes/laboratory control samples
- Blind field duplicates
- Laboratory duplicates
- Frequency of QC samples
- Corrective action records
- Completeness
- Overall assessment of data quality.

In the event that a portion of the data is outside the specified control limits, or sample collection and/or documentation practices are deficient, corrective action(s) will be initiated. Corrective action, as described in Section 3.5, will be determined by the field coordinator and Landau Associates' QA Officer in consultation with the Landau Associates' project and task managers and may include any of the following:

- Rejection of the data and resampling
- Qualification of the data
- Modified field and/or laboratory procedures.

The results of the data validation will be documented in a technical memorandum and submitted to EPA with monthly progress reports. Data qualification arising from data validation activities will be described in a data validation technical memorandum, rather than in an individual corrective action report, and included in the data base and any tables summarizing the data. The data validation technical memorandum will include a disk with electronic copies of chain of custody forms and laboratory data packages. This monthly reporting requirement is in effect until such time that EPA approves of alternate reporting requirements.

3.7 DATA ANALYSIS PROCEDURES

Monitoring data from LS431 will be compared to the interim goals for discharge to Slip 4 as stated in the ASAOC and in this document. LTST influent and effluent data will be compared to determine LTST system performance and will influence any operational changes to the system, if necessary. Sediment trap data will be used to continue evaluation of individual storm drain line inputs, and may influence future source control activities and remedial actions. Weir tank, storage tank, and sand filter media data will be used for waste characterization and will affect disposal procedures. Data from the re-routed King County stormwater line will be used to determine whether contaminant concentrations in King County water are adversely affecting the ability of the LTST system to meet interim goals at LS431, and will influence decisions on whether to re-route the water away from the LTST system.

* * * * * * *

This document has been prepared under the supervision and direction of the following key staff.

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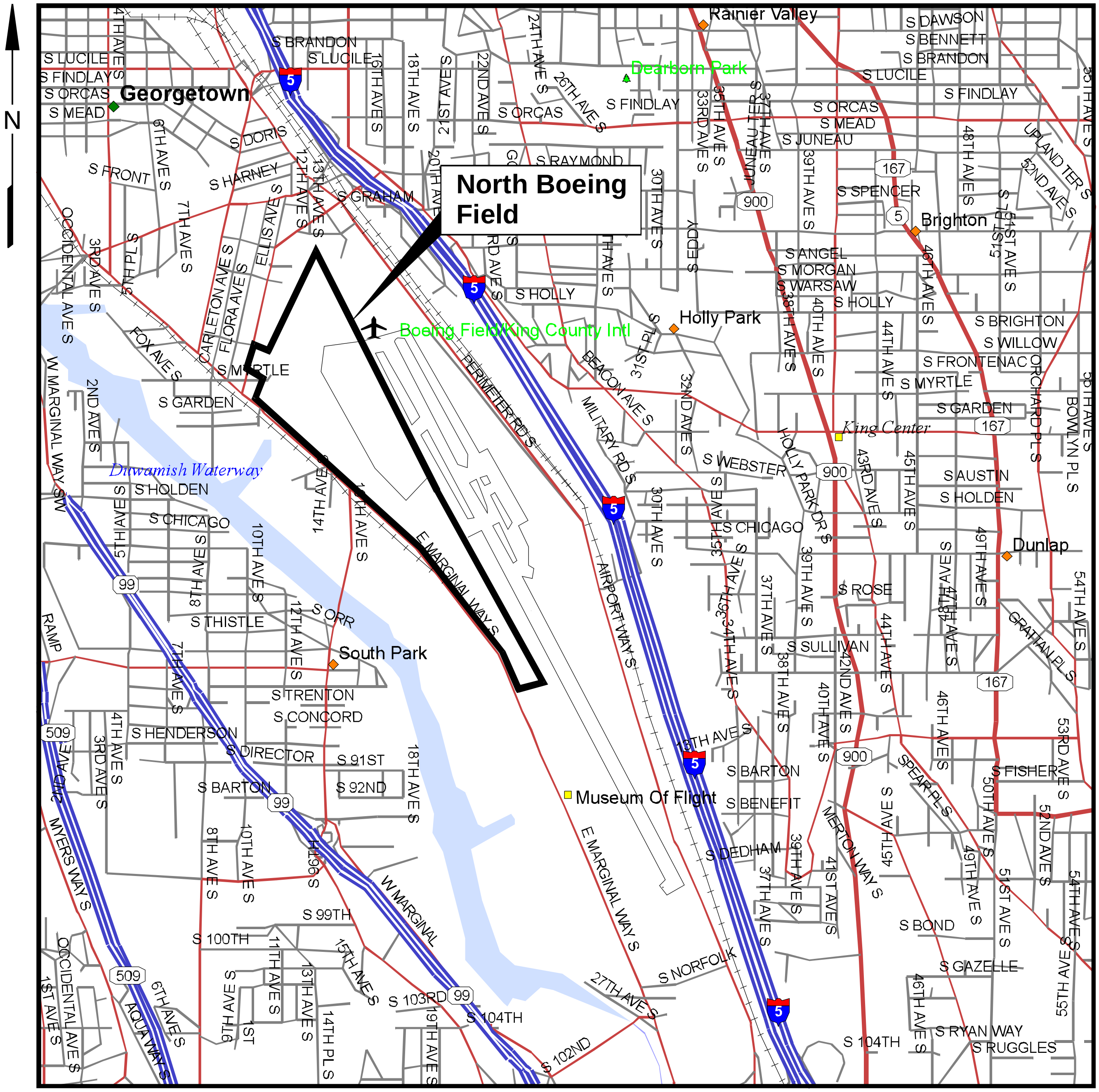


Map from DeLorme Street Atlas USA, 2002

Flume Realignment| V:\025\082\089\SD Structure & Surface Solids Investigation\Figure 1.cdr 8/29/2009

LANDAU ASSOCIATES

North Boeing Field Seattle, Washington	**Vicinity Map**	Figure 1

Legend

Sediment Trap	NBF Storm Drain Structures	North Lateral Drain Line	South Lateral Drain Line
Lift Station	Manhole 108	North-Central Lateral Drain Line	Drainage from Building 3-380 Area
	Short-Term Stormwater Treatment Facility	South-Central Lateral Drain Line	Drainage from parking lot area

Note
1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Data Source: SAIC

0 160 320

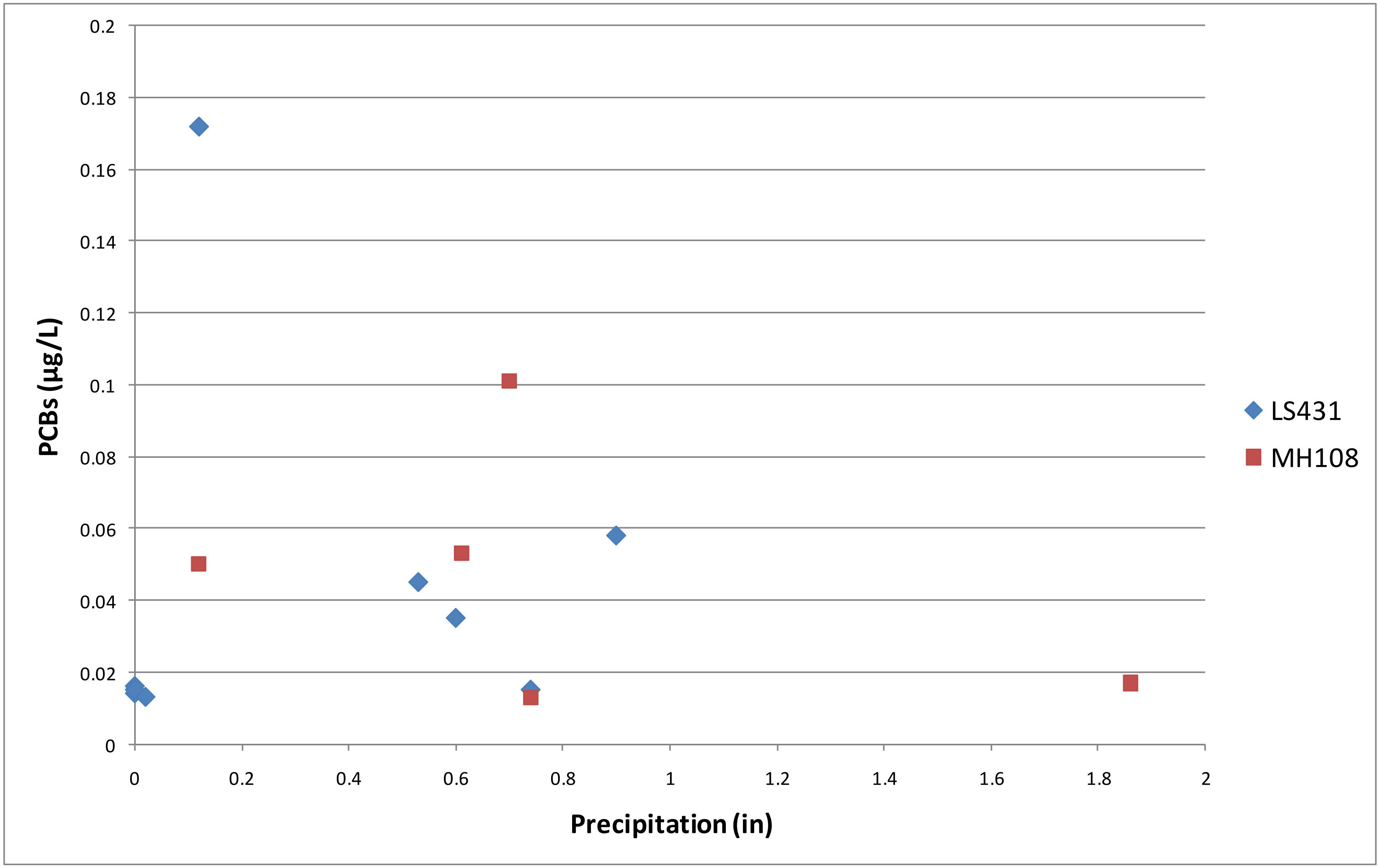
Scale in Feet

LANDAU ASSOCIATES

North Boeing Field
Seattle, Washington

STST Sampling Locations

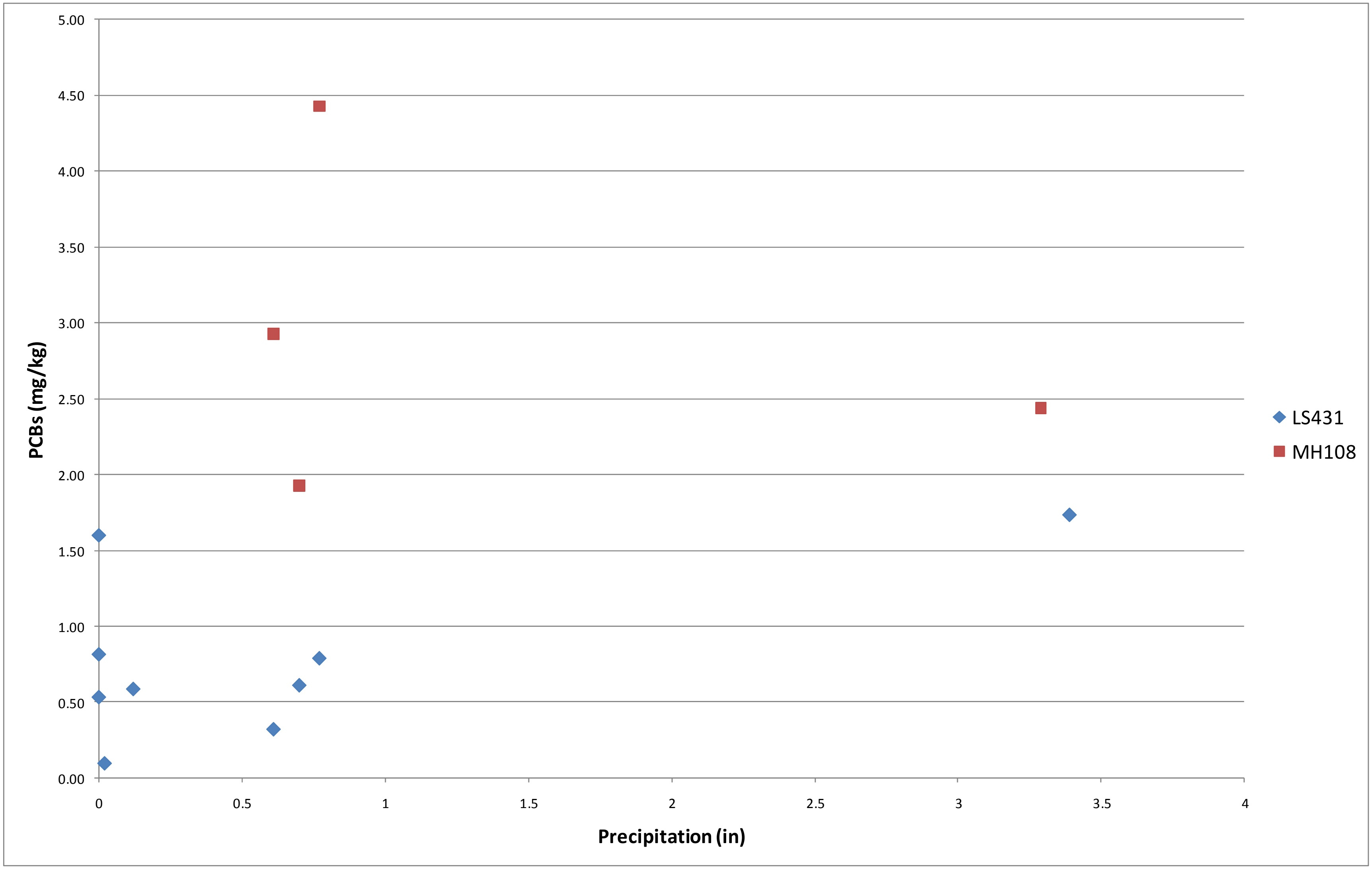
Figure
2



Note: Data Presented is From Sampling Events Conducted From November 2010 to March 2011.

LANDAU ASSOCIATES

North Boeing Field Seattle, Washington	**Whole Water PCB Concentrations vs. Precipitation**	Figure 3



Note: Data Presented is From Sampling Events Conducted From November 2010 to March

LANDAU ASSOCIATES

North Boeing Field Seattle, Washington	**Filtered Solids PCB Concentrations vs. Precipitation**	Figure 4

Legend

- Sediment Trap
- Lift Station Sampling Point
- NBF Storm Drain Structures
- Manhole 130A
- Long-Term Stormwater Treatment Facility
- North Lateral Drain Line
- North-Central Lateral Drain Line
- South-Central Lateral Drain Line
- South Lateral Drain Line
- Drainage from Building 3-380 Area
- Drainage from Parking Lot Area

Note
1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Data Source: SAIC

0 160 320
Scale in Feet

Landau Associates

North Boeing Field
Seattle, Washington

LTST Sampling Locations

Figure
5

Y:\Projects\025082\MapDocs\311\SAP (Sampling and Analysis Plan)\Fig5-SamplingLocations.mxd 6/23/2011 NAD 1983 StatePlane Washington North FIPS 4601 Feet

TABLE 1
LS431 AND MH108 STORMWATER ANALYTICAL RESULTS
NORTH BOEING FIELD
SEATTLE, WASHINGTON

Sample Location ID	NBF-LS431-111710-W	NBF-LS431-113010-W	NBF-LS431-121110-W	NBF-LS431-012111-W	NBF-LS431-012811-W	NBF-LS431-030911-W	NBF-LS431-032111-W	NBF-MH108-111710-W	NBF-MH108-113010-W	NBF-MH108-121210-W	NBF-MH108-012111-W	NBF-MH108-030911-W
Sample Collection Date	11/17/10	11/30/2010	12/11/2010	01/21/2011	01/28/2011	03/09/2011	03/21/2011	11/17/10	11/30/2010	12/12/2010	01/21/2011	03/09/2011
PCBs in Whole Water (a)												
Total PCBs (µg/L)	**0.172**	**0.015**	**0.058**	**0.035**	0.015 U	**0.045**	**0.013**	**0.050**	**0.013**	**0.017**	**0.053**	**0.101**
PRECIPITATION (b)												
Amount During Test (inches)	0.12	0.74	0.90	0.60	0	0.53	0.02	0.12	0.74	1.86	0.61	0.70

Sample Location ID	NBF-LS431A-111710-S	NBF-LS431A-113010-S	NBF-LS431A-121210-S	NBF-LS431A-012111-S	NBF-LS431A-012811-S	NBF-LS431A-030911-S	NBF-LS431A-032111-S	NBF-MH108A-111710-S	NBF-MH108A-113010-S	NBF-MH108A-121210-S	NBF-MH108A-012111-S	NBF-MH108A-030911-S
Sample Collection Date	11/17/10	11/30/10	12/12/10	01/21/2011	01/28/2011	03/09/2011	03/21/2011	11/17/10	11/30/10	12/12/10	01/21/2011	03/09/2011
PCBs in Filtered Solids												
Calculated Concentration of Total PCBs in Filtered Solids, Dry Weight (mg/kg)	**0.58**	**0.79**	**1.7**	**0.32**	**0.81**	**0.61**	**0.09**	NA	**4.4**	**2.4**	**2.9**	**1.9**
PRECIPITATION (b)												
Amount During Test (inches)	0.12	0.77	3.39	0.61	0	0.70	0.02	0.12	0.77	3.29	0.61	0.70

NA = Not Analyzed.
Bold = Detected compound.
U = Indicates the compound was undetected at the reported concentration.
Blue = Validation process not completed.

(a) Total PCBs is the sum of detected aroclors or, if no aroclors are detected, is the largest reporting limit.
(b) Precipitation data is from the NOAA Quality Controlled Local Climatological Data for Station 24234/BFI - SEATTLE: BOEING FIELD/KING COUNTY INTERNATIONAL AIRPORT.

TABLE 2
LONG-TERM REMOVAL ACTION SAMPLING AND ANALYSIS SUMMARY
NORTH BOEING FIELD
SEATTLE, WASHINGTON

Location	Sample Type	Sample Media	Frequency (a)	Parameters	Analytical Methods
Lift Station (LS 431) (Compliance Monitoring Point)	Whole Water (flow-weighted composite)	Stormwater (b)	Monthly routine sampling (multiple day sampling period) and two additional 24-hour storm events of ≥0.5 inch precipitation, September 30, 2011 - April 30, 2012	PCBs	EPA Method 8082
				TSS	SM 2540
				Total & Dissolved Metals (k)	EPA Methods 200.8, 7470 for Hg
				SVOCs (k)	EPA Method 8270
			Routine (monthly) & storm event sampling, September 30, 2011 - December 31, 2011	Particle Size Distribution	Ecology TAPE Method (m)
			To be determined (c), starting May 2012, or January 2012 for Particle Size Distribution	PCBs	EPA Method 8082
				TSS	SM 2540
				Total & Dissolved Metals (k)	EPA Methods 200.8, 7470 for Hg
				SVOCs (k)	EPA Method 8270
				Particle Size Distribution	Ecology TAPE Method (m)
	Filtered Solids (in-line stormwater filtration)	Stormwater Solids	Monthly routine sampling (multiple day sampling period) and two additional 24-hour storm events of ≥0.5 inch precipitation, September 30, 2011 - April 30, 2012	PCBs	EPA Method 8082
				Metals (l)	EPA Methods 6010, 7471 for Hg
			To be Determined (c), starting May 2012	PCBs	EPA Method 8082
				Metals (l)	EPA Methods 6010, 7471 for Hg
Long-Term Stormwater Treatment System	Whole Water Influent from MH130A (grab)	Stormwater (b)	Twice monthly in 2011, Monthly starting 2012 (d)	PCBs	EPA Method 8082
				TSS	SM 2540
	Whole Water Influent from Lift Station Inlet Vault (grab)	Stormwater (b)	Twice monthly in 2011, Monthly starting 2012 (d)	PCBs	EPA Method 8082
				TSS	SM 2540
	Whole Water Effluent (grab)	Stormwater (b)	Twice monthly in 2011, Monthly starting 2012 (d)	PCBs	EPA Method 8082
				TSS	SM 2540
	Whole Water Effluent (grab) (e)	Stormwater (b)	Twice monthly (f)	Residual Chitosan	Ecology approved procedure (g)
	Filtered Solids Influent from MH130A	Stormwater Solids	Twice monthly in 2011, Monthly starting 2012	PCBs	EPA Method 8082
	Filtered Solids Influent from Lift Station Inlet Vault	Stormwater Solids	Twice monthly in 2011, Monthly starting 2012	PCBs	EPA Method 8082
	Filtered Solids Effluent	Stormwater Solids	Twice monthly in 2011, Monthly starting 2012	PCBs	EPA Method 8082

TABLE 2
LONG-TERM REMOVAL ACTION SAMPLING AND ANALYSIS SUMMARY
NORTH BOEING FIELD
SEATTLE, WASHINGTON

Location	Sample Type	Sample Media	Frequency (a)	Parameters	Analytical Methods
Sediment Traps (SL4-T1, SL4-T2, SL4-T3, SL4-T4, SL4-T4A, SL4-T5, SL4-T5A) (SL4-T5A to be moved from MH178 to "Buried Manhole" after re-route)	Annual Composite, Homogenized	Stormwater Solids	Annually (h)	PCBs	EPA Method 8082
				Semivolatiles	PSDDA SVOCS SW8270D
				Total Metals	Method 6000-7000
				NWTPH-Dx	NWTPH-Dx
				Total Organic Carbon	Plumb, 1981
				Particle Size Distribution	PSEP-PS (j)
Weir and Storage Tanks, Sand Filter Media	Composite from 3 or More Grab Samples from Tank or Filter Vessel (grab locations to result in both horizontal and vertical compositing)	Settled Solids	As Needed (i)	PCBs	EPA Method 8082
				SVOCs	EPA Method 8270D
				Metals	TCLP and/or Method 6000-7000
				Petroleum Hydrocarbons	NWTPH-Dx and NWTPH-Gx
Re-routed King County Stormwater (at new "Wet Well" vault upstream of LS431)	Whole Water (flow-weighted composite)	Stormwater (b)	Three events parallel w/ LS431, September 30, 2011 - April 30, 2012	PCBs	EPA Method 8082
				TSS	SM 2540
				Particle Size Distribution	Ecology TAPE Method (m)
			To be determined (c), starting May 2012	PCBs	EPA Method 8082
				TSS	SM 2540
				Particle Size Distribution	Ecology TAPE Method (m)
	Filtered Solids (in-line stormwater filtration)	Stormwater Solids	Three events parallel w/ LS431, September 30, 2011 - April 30, 2012	PCBs	EPA Method 8082
			To be Determined (c), starting May 2012	PCBs	EPA Method 8082

(a) Monitoring plan beginning September 2011. All sampling and analysis will be performed by Boeing/Landau Associates and Boeing's contract laboratory, unless otherwise noted.
(b) Stormwater is defined as all liquids, including any particles dissolved therein, in the form of base flow, storm water runoff, snow melt runoff, and drainage, as well as all solids which enter the storm drain system.
(c) Boeing will propose to EPA a sampling frequency based on the results from the initial sampling events.
(d) One LTST system influent/effluent sampling event per month will be performed during the monthly lift station (LS431) sampling event.
(e) Whole water effluent grab samples for Residual Chitosan testing will be collected from the treatment facility effluent sample port by Clear Water Compliance Services.
(f) Residual chitosan has never been detected in eight months of weekly effluent samples from the STST facility, and there is extremely low probability of chitosan being able to pass through the sand filters.
(g) Per CESF system O&M Manual, Ecology approves procedures for residual chitosan testing for each chitosan distributor. Testing will be conducted in accordance with distributor's approved procedures.
(h) Depending on the quantity of solids collected in the sediment traps, the laboratory may not be able to analyze all parameters. Analysis of parameters will be prioritized in the order listed. Sediment trap sampling will continue indefinitely until such time that additional data collection is no longer needed to support source control efforts.
(i) The thickness of accumulated solids (sludge) in the weir tank will be checked at least once per month to determine if solids should be removed. Prior to solids removal, a composite sample of the solids will be collected and analyzed for waste characterization purposes. Composite sampling will also be done for used sand filter media prior to disposal. Subsequent waste characterization will not be necessary unless contaminant concentrations in the LTST influent change significantly.
(j) Grain size fractionation/particle size distribution will be conducted using Puget Sound Estuary Protocols (PSEP) method. When low volumes of sample are collected, grain size fractionation will be accomplished using sedigraph for material less than 62.5 µm.
(k) If sufficient volume is available, LS431 whole water samples will be analyzed for total and dissolved metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc) and SVOCs to support Ecology's NBF-GTSP remedial investigation activities.
(l) If sufficient volume is available, LS431 filtered solids samples will be analyzed for metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc) to support Ecology's NBF-GTSP remedial investigation activities.
(m) Method may change. The preferred method for particle size distribution analysis is being determined.

TABLE 3
ANALYTICAL METHODS AND TARGET REPORTING LIMITS
LONG-TERM STORMWATER TREATMENT FACILITY SAMPLING
NORTH BOEING FIELD
SEATTLE, WASHINGTON

Analyte	Analytical Method (a)	Target Reporting Limits (b)			
			Filtered	Unfiltered Solids	
		Water	Solids	Sediment Traps	Residual Solids
PCBs					
Aroclor 1016	EPA Method 8082 (c)	0.01 µg/L	5 µg	10 µg/kg	33 µg/kg
Aroclor 1221	EPA Method 8082 (c)	0.01 µg/L	5 µg	10 µg/kg	33 µg/kg
Aroclor 1232	EPA Method 8082 (c)	0.01 µg/L	5 µg	10 µg/kg	33 µg/kg
Aroclor 1242	EPA Method 8082 (c)	0.01 µg/L	5 µg	10 µg/kg	33 µg/kg
Aroclor 1248	EPA Method 8082 (c)	0.01 µg/L	5 µg	10 µg/kg	33 µg/kg
Aroclor 1254	EPA Method 8082 (c)	0.01 µg/L	5 µg	10 µg/kg	33 µg/kg
Aroclor 1260	EPA Method 8082 (c)	0.01 µg/L	5 µg	10 µg/kg	33 µg/kg
Aroclor 1262	EPA Method 8082 (c)	0.01 µg/L	5 µg	--	--
CONVENTIONALS					
Total Suspended Solids	SM 2540	1 mg/L	--	--	--
Total Organic Carbon	Plumb 1981	--	--	0.02 percent	--
PARTICLE SIZE DISTRIBUTION					
Particle Size Distribution	PSEP-PS/Ecology TAPE Method	--	--	--	--
Total Petroleum Hydrocarbons					
Diesel-Range	NWTPH-Dx (d,e)	--	--	5.0 mg/kg	5.0 mg/kg
Motor Oil-Range	NWTPH-Dx (d,e)	--	--	10.0 mg/kg	10.0 mg/kg
Gasoline-Range	NWTPH-Gx (d)	--	--	--	5.0 mg/kg
METALS					
Arsenic	EPA Method 200.8/6010	0.5 µg/L	5.0 mg/kg	5.0 mg/kg	5.0 mg/kg
Cadmium	EPA Method 200.8/6010	0.1 µg/L	0.2 mg/kg	--	0.2 mg/kg
Chromium	EPA Method 200.8/6010	0.5 µg/L	0.5 mg/kg	--	0.5 mg/kg
Copper	EPA Method 200.8/6010	0.5 µg/L	0.2 mg/kg	0.2 mg/kg	0.2 mg/kg
Lead	EPA Method 200.8/6010	0.1 µg/L	2.0 mg/kg	2.0 mg/kg	2.0 mg/kg
Mercury	EPA Method 7470/7471	0.02 µg/L	0.025 mg/kg	0.025 mg/kg	0.025 mg/kg
Nickel	EPA Method 200.8/6010	0.5 µg/L	1.0 mg/kg	--	1.0 mg/kg
Zinc	EPA Method 200.8/6010	4.0 µg/L	1.0 mg/kg	1.0 mg/kg	1.0 mg/kg
TCLP METALS					
Arsenic	EPA Method 1311/6010	0.2 mg/L	--	--	--
Barium	EPA Method 1311/6010	0.2 mg/L	--	--	--
Cadmium	EPA Method 1311/6010	0.01 mg/L	--	--	--
Chromium	EPA Method 1311/6010	0.02 mg/L	--	--	--
Lead	EPA Method 1311/6010	0.1 mg/L	--	--	--
Mercury	EPA Method 1311/7471	0.0001 mg/L	--	--	--
Selenium	EPA Method 1311/6010	0.2 mg/L	--	--	--
Silver	EPA Method 1311/6010	0.02 mg/L	--	--	--
SEMIVOLATILES					
Phenol	SW 8270D (f)	1.0 µg/L	--	20 µg/kg	67 µg/kg
Bis-(2-Chloroethyl) Ether	SW 8270D (f)	--	--	--	67 µg/kg
2-Chlorophenol	SW 8270D (f)	--	--	--	67 µg/kg
1,3-Dichlorobenzene	SW 8270D (f)	--	--	20 µg/kg	67 µg/kg
1,4-Dichlorobenzene	SW 8270D (f)	1.0 µg/L	--	20 µg/kg	67 µg/kg
Benzyl Alcohol	SW 8270D (f)	5.0 µg/L	--	20 µg/kg	330 µg/kg
1,2-Dichlorobenzene	SW 8270D (f)	1.0 µg/L	--	20 µg/kg	67 µg/kg
2-Methylphenol	SW 8270D (f)	1.0 µg/L	--	20 µg/kg	67 µg/kg
2,2'-Oxybis(1-Chloropropane)	SW 8270D (f)	--	--	--	67 µg/kg
4-Methylphenol	SW 8270D (f)	1.0 µg/L	--	20 µg/kg	67 µg/kg
N-Nitroso-Di-N-Propylamine	SW 8270D (f)	--	--	--	67 µg/kg
Hexachloroethane	SW 8270D (f)	--	--	20 µg/kg	67 µg/kg
Nitrobenzene	SW 8270D (f)	--	--	--	67 µg/kg
Isophorone	SW 8270D (f)	--	--	--	67 µg/kg
2-Nitrophenol	SW 8270D (f)	--	--	--	67 µg/kg
2,4-Dimethylphenol	SW 8270D (f)	1.0 µg/L	--	20 µg/kg	67 µg/kg
Benzoic Acid	SW 8270D (f)	10.0 µg/L	--	100 µg/kg	670 µg/kg
bis(2-Chloroethoxy) Methane	SW 8270D (f)	--	--	--	67 µg/kg
2,4-Dichlorophenol	SW 8270D (f)	--	--	--	330 µg/kg

TABLE 3
ANALYTICAL METHODS AND TARGET REPORTING LIMITS
LONG-TERM STORMWATER TREATMENT FACILITY SAMPLING
NORTH BOEING FIELD
SEATTLE, WASHINGTON

Analyte	Analytical Method (a)	Target Reporting Limits (b)			
		Water	Filtered Solids	Unfiltered Solids: Sediment Traps	Unfiltered Solids: Residual Solids
1,2,4-Trichlorobenzene	SW 8270D (f)	1.0 µg/L	--	100 µg/kg	67 µg/kg
Naphthalene	SW 8270D (f)	1.0 µg/L	--	20 µg/kg	67 µg/kg
4-Chloroaniline	SW 8270D (f)	--	--	--	330 µg/kg
Hexachlorobutadiene	SW 8270D (f)	1.0 µg/L	--	20 µg/kg	67 µg/kg
4-Chloro-3-methylphenol	SW 8270D (f)	--	--	--	330 µg/kg
1-Methylnaphthalene	SW 8270D (f)	--	--	20 µg/kg	67 µg/kg
2-Methylnaphthalene	SW 8270D (f)	1.0 µg/L	--	100 µg/kg	67 µg/kg
Hexachlorocyclopentadiene	SW 8270D (f)	--	--	--	330 µg/kg
2,4,6-Trichlorophenol	SW 8270D (f)	--	--	--	330 µg/kg
2,4,5-Trichlorophenol	SW 8270D (f)	--	--	--	330 µg/kg
2-Chloronaphthalene	SW 8270D (f)	--	--	--	67 µg/kg
2-Nitroaniline	SW 8270D (f)	--	--	--	330 µg/kg
SEMIVOLATILES (continued)					
Dimethylphthalate	SW 8270D (f)	1.0 µg/L	--	100 µg/kg	67 µg/kg
Acenaphthylene	SW 8270D (f)	1.0 µg/L	--	20 µg/kg	67 µg/kg
3-Nitroaniline	SW 8270D (f)	--	--	--	330 µg/kg
Acenaphthene	SW 8270D (f)	1.0 µg/L	--	100 µg/kg	67 µg/kg
2,4-Dinitrophenol	SW 8270D (f)	--	--	--	670 µg/kg
4-Nitrophenol	SW 8270D (f)	--	--	--	330 µg/kg
Dibenzofuran	SW 8270D (f)	1.0 µg/L	--	100 µg/kg	67 µg/kg
2,6-Dinitrotoluene	SW 8270D (f)	--	--	--	330 µg/kg
2,4-Dinitrotoluene	SW 8270D (f)	--	--	--	330 µg/kg
Diethylphthalate	SW 8270D (f)	1.0 µg/L	--	100 µg/kg	67 µg/kg
4-Chlorophenyl-phenylether	SW 8270D (f)	--	--	--	67 µg/kg
Fluorene	SW 8270D (f)	1.0 µg/L	--	20 µg/kg	67 µg/kg
4-Nitroaniline	SW 8270D (f)	--	--	--	330 µg/kg
4,6-Dinitro-2-Methylphenol	SW 8270D (f)	--	--	--	670 µg/kg
N-Nitrosodiphenylamine	SW 8270D (f)	1.0 µg/L	--	20 µg/kg	67 µg/kg
4-Bromophenyl-phenylether	SW 8270D (f)	--	--	--	67 µg/kg
Hexachlorobenzene	SW 8270D (f)	1.0 µg/L	--	20 µg/kg	67 µg/kg
Pentachlorophenol	SW 8270D (f)	5.0 µg/L	--	20 µg/kg	330 µg/kg
Phenanthrene	SW 8270D (f)	1.0 µg/L	--	20 µg/kg	67 µg/kg
Carbazole	SW 8270D (f)	--	--	--	67 µg/kg
Anthracene	SW 8270D (f)	1.0 µg/L	--	20 µg/kg	67 µg/kg
Di-n-Butylphthalate	SW 8270D (f)	1.0 µg/L	--	20 µg/kg	67 µg/kg
Fluoranthene	SW 8270D (f)	1.0 µg/L	--	20 µg/kg	67 µg/kg
Pyrene	SW 8270D (f)	1.0 µg/L	--	100 µg/kg	67 µg/kg
Butylbenzylphthalate	SW 8270D (f)	1.0 µg/L	--	20 µg/kg	67 µg/kg
3,3'-Dichlorobenzidine	SW 8270D (f)	--	--	--	330 µg/kg
Benzo(a)anthracene	SW 8270D (f)	1.0 µg/L	--	20 µg/kg	67 µg/kg
bis(2-Ethylhexyl)phthalate	SW 8270D (f)	1.0 µg/L	--	20 µg/kg	67 µg/kg
Chrysene	SW 8270D (f)	1.0 µg/L	--	20 µg/kg	67 µg/kg
Benzo(b,k)fluoranthene	SW 8270D (f)	1.0 µg/L	--	20 µg/kg	67 µg/kg
Di-n-Octyl phthalate	SW 8270D (f)	1.0 µg/L	--	20 µg/kg	67 µg/kg
Benzo(a)pyrene	SW 8270D (f)	1.0 µg/L	--	20 µg/kg	67 µg/kg
Indeno(1,2,3-cd)pyrene	SW 8270D (f)	1.0 µg/L	--	20 µg/kg	67 µg/kg
Dibenz(a,h)anthracene	SW 8270D (f)	1.0 µg/L	--	20 µg/kg	67 µg/kg
Benzo(g,h,i)perylene	SW 8270D (f)	1.0 µg/L	--	20 µg/kg	67 µg/kg

SM = Standard Method

(a) Analytical methods are from SW-846 (EPA 1986) and updates unless otherwise noted.

(b) Reporting limits goals are based on current laboratory data and may be modified during the investigation process as methodology is refined. Laboratory reporting will be based on the lowest standard on the calibration curve. Instances may arise where high sample concentrations, nonhomogeneity of samples, total solids (percent of sample that is solids), or matrix interferences preclude achieving the desired reporting limits.

(c) Unfiltered solids will be analyzed by PSDDA Method 8082.

(d) Methods NWTPH-Dx and NWTPH-Gx as described in *Analytical Methods for Petroleum Hydrocarbons* Washington State Department of Ecology, Publication ECY97-602, June 1997 (Ecology 1997)

(e) An acid silica gel cleanup cleanup will be performed for all NWTPH-Dx analyses.

(f) Sediment trap samples will be analyzed by PSDDA Method 8270D.

TABLE 4
SAMPLE CONTAINERS, PRESERVATIVES, AND HOLDING TIME REQUIRMENTS
LONG-TERM STORMWATER TREATMENT FACILITY SAMPLING
NORTH BOEING FIELD
SEATTLE, WASHINGTON

Analyte	Analytical Method	LS431 Whole Water Stormwater Samples				LS431 Filtered Solids Samples				Stormwater Treatment Facility Whole Water Influent/Effluent Samples				Stormwater Treatment Facility Influent/Effluent Filtered Solids			
		Volume Required	Container	Preservation	Holding Time	Volume Required	Container	Preservation	Holding Time	Volume Required	Container	Preservation	Holding Time	Volume Required	Container	Preservation	Holding Time
PCBs	EPA SW8082/PSDAA 8082	2 Liters	5-gallon glass carboy	Store cool at 6°C	After churn split, 7 days to extraction, 40 days to analysis	N/A [2]	Filter Bag	Store cool at 6°C	14 days to extraction, 40 days to analysis	2 Liters	1 Liter Amber Glass	Store cool at 6°C	7 days to extraction, 40 days to analysis	N/A [2]	Filter Bag	Store cool at 6°C	14 days to extraction, 40 days to analysis
TSS	SM 2540 D-97	2 Liters		Store cool at 6°C	7 days after they are churn split	--	--	--	--	2 Liters	1 L HDPE	Store cool at 6°C	7 Days	--	--	--	--
Total and Dissolved Metals	EPA 200.8	1 Liter		Store cool at 6°C, Nitric Acid in lab	6 months after churn split, filtering for dissolved metals, and preservation in lab	--	--	--	--	--	--	--	--	--	--	--	--
Total and Dissolved Mercury	EPA 7470					--	--	--	--	--	--	--	--	--	--	--	--
Particle Size Distribution	Ecology TAPE	1 Liter		Store cool at 6°C	7 days after they are churn split	--	--	--	--	--	--	--	--	--	--	--	--
	PSEP-PS	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Diesel-range and motor-oil range petroleum hydrocarbons	NWTPH-Dx	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Gasoline-Range Petroleum Hydrocarbons	NWTPH-Gx	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Total Organic Carbon	Plumb, 1981	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SVOCs	EPA 8270/PSDDA SW8270D	1 Liter	5-gallon glass carboy	Store cool at 6°C	After churn split, 7 days to extraction, 40 days to analysis	--	--	--	--	--	--	--	--	--	--	--	--
TCLP Metals	EPA 6010/7470	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Metals	EPA SW6010	--	--	--	--	3 grams	Filter Bag	Store cool at 6°C	6 months	--	--	--	--	--	--	--	--
Mercury	EPA SW7471	--	--	--	--	0.2 gram	Filter Bag	Store cool at 6°C	28 days	--	--	--	--	--	--	--	--

TABLE 4
SAMPLE CONTAINERS, PRESERVATIVES, AND HOLDING TIME REQUIRMENTS
LONG-TERM STORMWATER TREATMENT FACILITY SAMPLING
NORTH BOEING FIELD
SEATTLE, WASHINGTON

Analyte	Analytical Method	Sediment Traps				Weir Tank, Backflush Tank, and Sand Filtration Units Residual Solids				Re-routed King County Whole Water Stormwater Samples				Re-routed King County Filtered Solids Samples			
		Volume Required	Container	Preservation	Holding Time	Volume Required	Container	Preservation	Holding Time	Volume Required	Container	Preservation	Holding Time	Volume Required	Container	Preservation	Holding Time
PCBs	EPA SW8082/PSDAA 8082	8 oz. (3)	Teflon Bottle	Store cool at 6°C	14 days to extraction, 40 days to analysis	8 oz.	8 oz. WMG	Store cool at 6°C	14 days to extraction, 40 days to analysis	2 Liters	5-gallon glass carboy	Store cool at 6°C	After churn split, 7 days to extraction, 40 days to analysis	N/A (2)	Filter Bag	Store cool at 6°C	14 days to extraction, 40 days to analysis
TSS	SM 2540 D-97	--	--	--	--	--	--	--	--	2 Liters		Store cool at 6°C	7 days after they are churn split	--	--	--	--
Total and Dissolved Metals	EPA 200.8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Total and Dissolved Mercury	EPA 7470	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Particle Size Distribution	Ecology TAPE	--	--	--	--	--	--	--	--	1 Liter	5-gallon glass carboy	Store cool at 6°C	7 days after they are churn split	--	--	--	--
	PSEP-PS	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Diesel-range and motor-oil range petroleum hydrocarbons	NWTPH-Dx	8 oz. (3)	Teflon Bottle	Store cool at 6°C	14 days to extraction, 40 days to analysis	8 oz.	8 oz. WMG	Store cool at 6°C	14 days to extraction, 40 days to analysis	--	--	--	--	--	--	--	--
Gasoline-Range Petroleum Hydrocarbons	NWTPH-Gx	--	--	--	--	2 oz.	2 oz. WMGS (1)	Store cool at 6°C	14 days	--	--	--	--	--	--	--	--
Total Organic Carbon	Plumb, 1981	4 oz. (3)	Teflon Bottle	Store cool at 4°C	14 days	--	--	--	--	--	--	--	--	--	--	--	--
SVOCs	EPA 8270/PSDDA SW8270D	8 oz. (3)	Teflon Bottle	Store cool at 6°C	14 days	8 oz.	8 oz. WMG	Store cool at 6°C	14 days	--	--	--	--	--	--	--	--
TCLP Metals	EPA 6010/7470	--	--	--	--	8 oz	8 oz. WMG	Store cool at 6°C	28/180 days to TCLP extraction, 28/180 days to analysis (Hg/all other metals)	--	--	--	--	--	--	--	--
Metals	EPA SW6010	4 oz. (3)	Teflon Bottle	Store cool at 6°C	6 months	--	--	--	--	--	--	--	--	--	--	--	--
Mercury	EPA SW7471		Teflon Bottle	Store cool at 6°C	28 days	--	--	--	--	--	--	--	--	--	--	--	--

TCLP = Toxicity Characteristic Leachate Procedure
PCB = Polychlorinated biphenyl
SVOC = Semivolatile organic compound

oz. = ounce
AG = amber glass boston round bottle
HDPE = High Density Polypropylene
WMG = wide mouth glass jar
WMGS = wide mouth glass jar with septa lid

Notes:
1. No headspace.
2. The entire filter bag (filter material and collected material) is analyzed for PCBs, regardless of the volume of solids collected in the bag.
3. Amount of settled solids collected in Teflon bottle is not anticipated to meet required sample volumes. Laboratory will pre-screen samples and cut back on volumes required based on pre-screens. Analysis is prioritized due to limited volume.

APPENDIX D

Operation and Maintenance Manual for Long-Term Stormwater Treatment

Operations and Maintenance Manual
Long-Term Stormwater Treatment Facility
North Boeing Field
Seattle, Washington

June 24, 2011

Prepared for

The Boeing Company
Seattle, Washington

TABLE OF CONTENTS

TABLES

ATTACHMENTS

1.0 INTRODUCTION

This operation and maintenance (O&M) manual presents recommended operation, maintenance, monitoring, and testing procedures related to the long-term stormwater treatment (LTST) system at North Boeing Field (NBF). The LTST system is designed to remove polychlorinated biphenyls (PCBs) from stormwater in the storm drain system at NBF. On September 29, 2010, Boeing entered into an Administrative Settlement Agreement and Order on Consent for Removal Action (ASAOC) with the U.S. Environmental Protection Agency (EPA). This O&M manual is a required deliverable under the ASAOC, which requires that Boeing address the discharge of PCBs to the Slip 4 Early Action Area (EAA) through short-term and long-term stormwater treatment removal actions. Because this draft of the manual was written prior to construction or design completion, significant details may change or be added before this document is finalized. Following system startup and initial operation, this O&M manual will be updated as determined to be necessary and provided to EPA along with the Construction Completion Report.

Most of the PCBs discharging from NBF to Slip 4 via the NBF storm drain system were previously identified to be from the North Lateral portion of the storm drain (SAIC 2010). Under the ASAOC, Boeing installed the short-term stormwater treatment (STST) facility to remove PCBs from a large portion of the North Lateral portion of the NBF storm drain system prior to discharge to Slip 4 (Landau Associates 2010a, 2011a). The STST facility consists of a chitosan-enhanced sand filtration (CESF) system that treats stormwater flow from a large portion of the North Lateral storm drain line at NBF. That system became operational on September 15, 2010. The STST facility will continue to operate under the oversight of the EPA until the LTST facility is installed and operating. The LTST facility discussed in this O&M manual is similar in function to the STST facility, although larger in scale to provide greater treatment of stormwater prior to discharge to Slip 4.

1.1 SITE LOCATION

NBF is located east of East Marginal Way South, adjacent to the King County International Airport (KCIA) and the City of Seattle Georgetown Steam Plant. The approximate street address is 7370 East Marginal Way South, Seattle, Washington. NBF is approximately 150 ft from the head of Slip 4, which is an EAA at approximately River Mile 2.8 on the Duwamish Waterway within the Lower Duwamish Waterway Superfund Site.

1.2 TREATMENT SYSTEM DESCRIPTION

Because PCB contamination is predominantly bound to suspended particles in the stormwater, removal of these particles is the most effective method of PCB removal. For stormwater CESF treatment, a liquid solution of chitosan acetate is typically dosed into the stormwater prior to a filtration step (e.g., sand filtration). Chitosan is a biopolymer that can be extracted from shrimp and crab shells. The chitosan agglomerates suspended solids, including small colloidal particles that are otherwise resistant to settling and filtration. The larger size and mass of the agglomerated particles facilitate efficient settling and filtration. CESF systems can effectively remove suspended solids, often achieving turbidity levels below 1 nephelometric turbidity unit (NTU) with a dosage of chitosan acetate of less than 1 part per million (ppm).

1.2.1 TREATMENT SYSTEM DESIGN BASIS

As described in the Long-Term Stormwater Treatment Removal Action Work Plan (RAWP) Addendum (Geosyntec 2011), the Final Pre-Design Technical Memorandum: Long-Term Stormwater Treatment (Geosyntec and Landau Associates 2011), and the Pre-Final (90%) Design Report: Long-Term Stormwater Treatment (Landau Associates 2011a), the following items describe the basis of LTST system design.

- The CESF system will be constructed near the King County lift station (LS431) to treat all dry weather base flows from the lift station and preferentially treat wet weather storm flows from the North Lateral from MH130A and, as capacity allows, additional flows from the lift station. The treatment system location and sizing will result in 91 percent capture and treatment of onsite storm flows to MH130A (12.8 acres), and 100 percent treatment of onsite and offsite dry weather base flows to the lift station (approximately 106 acres onsite plus approximately 191 acres offsite). Additional treatment of low storm flows at the lift station will also be provided when capacity is available.
- The submersible pump at MH130A will route wet weather storm and base flows from the onsite North Lateral directly to the CESF treatment system at the lift station. When LTST system capacity exists beyond that required to treat the "captured" onsite North Lateral storm flows, additional storm flows from the lift station will be pumped to the CESF to take advantage of the full system treatment capacity.
- Offsite stormwater from the North Lateral (41.1 acres of King County drainage) will be rerouted at a location upstream of MH178 through NBF to the lift station, upstream of the CESF intake. The purpose of this reroute will be to minimize overflow bypass at MH130A and allow preferential capture and treatment of onsite North Lateral storm flows. The reroute will also allow some treatment of offsite North Lateral flows (as well as other laterals) when capacity allows.
- Dry weather base flows from onsite and offsite laterals discharging to the lift station will be pumped to the CESF, which will discharge to the vault just downstream of the lift station.

1.2.2 TREATMENT SUMMARY

The following list provides a brief summary of the primary LTST system operations:

1. Stormwater is transferred from the North Lateral and nearby King County lift station (LS431) to the treatment system location (see Section 1.2.1 for capture / treatment design basis)
2. Large particles are settled-out in the Inlet Weir Tank
3. Stormwater is pumped through the control station for introduction of chitosan acetate
4. Sedimentation: Chitosan-enhanced sedimentation in the Storage Tanks
5. Stormwater is pumped again through the control station for an additional dose of chitosan acetate
6. Filtration: Chitosan-enhanced sand filtration in three multi-vessel sand filter units
7. Water quality testing: Turbidity monitoring of treated stormwater
8. Water meeting criteria (turbidity < 5 NTU) continues to discharge at Slip 4
9. Water not meeting criteria (turbidity ≥ 5 NTU) is recirculated back to the Storage Tanks for additional settling and CESF.

1.2.3 TREATMENT SYSTEM COMPONENTS

A brief description of the process equipment used at the LTST system is provided in the list below:

Stormwater Collection Pumps: Two pumps will transfer stormwater to the LTST system.

1. A 10 horsepower (hp) submersible electric pump (P-101) is installed at MH130A. This pump will operate at a minimum of 500 gallons per minute (gpm), and a throttling valve will be provided if a reduction in flow rate is necessary. The pump is additionally controlled by float activation with PUMP ON at approximate elevation 4.45 ft and PUMP OFF at approximate elevation 3.3 ft. A weir just downstream of the pump, in MH130B, is at approximate elevation 5.23 ft.
2. A 15 hp submersible electric pump (P-201) is installed at Lift Station inlet vault OWS421. This pump will be operated in conjunction with P-101 to achieve a maximum combined flow rate of 1,500 gpm. Pump P-201 is capable of operating between pumping flow rates of 750 gpm and 1,500 gpm. The actual flow rate from P-201 will be adjusted by variable frequency drive (VFD) motor, and controlled dependent on the flow rate from MH130A. The pump is additionally controlled by float activation with PUMP ON at approximate elevation –0.51 ft and PUMP OFF at approximate elevation –2.80 ft. Operation of this pump is intended to limit the rise of water in OWS421 so that the King County pumps at LS431 will not be activated unless the LTST system is treating its design capacity of 1,500 gpm.

Inlet Weir Tank: All stormwater routed to the LTST system enters the 18,000-gallon Inlet Weir Tank, constructed with baffles in an under-over configuration. This tank facilitates settling of large particles and also provides some retention capacity for floating oil prior to chitosan dosing. The tank is designed to remove particles and provide protection for downstream process equipment. Pump P-301 transfers stormwater from the Inlet Weir Tank and is capable of passing solids up to ⅞-inch diameter. Flow rates through this tank could reach a maximum of 1,739 gpm, which includes a combined total of 1,500 gpm stormwater from MH130A and the nearby lift station LS431, and 239 gpm from the sand-filter backflush operation.

Transfer Pumps: Four pumps will transfer fluids within the LTST facility.

1. A 40-hp centrifugal pump (P-301) will transfer fluids from the Inlet Weir Tank, through the monitoring and control unit for monitoring and chitosan injection, and then to the Storage Tanks for settling. The pump is capable of operating at pumping flow rates between 500 and 1,650 gpm adjusted by VFD. Multiple flow rate setpoints have been established based on the height of water in the Inlet Weir Tank, to avoid over-cycling the pump by increasing pumping flow rates when levels are high and reducing pumping flow rates when tank levels are low.
2. Three individual 20-hp centrifugal pumps (P-310A, P-310B, and P-310C, one for each sand filtration unit) will transfer stormwater from the Storage Tanks, through the monitoring and control unit for monitoring and additional chitosan injection, through a sand filtration unit, through the monitoring and control unit once again, and either toward discharge at Slip 4 or recirculated back to the Storage Tanks depending upon monitoring results.

Chitosan Injection System: The chitosan injection system consists of a chitosan storage tank (a 275-gallon tote, located inside the control trailer), a variable speed chemical metering pump, graduated cylinders for calibration, inline static mixers, and assorted tubing and control valves. Chitosan dosing occurs within the control trailer for two separate stages of the treatment train. Stormwater is dosed prior to entering the Storage Tanks, and again prior to entering the sand filtration unit.

Storage Tanks: For the LTST system, three approximately 21,000-gallon steel aboveground storage tanks (ASTs) facilitate sedimentation prior to sand filtration. Piping influent to each of the tanks is manifolded together so that the tanks will share an equal amount of flow-through, and maintain similar levels of water. Flow through each of these tanks will be approximately one-third of the flow through the Inlet Weir Tank.

Sand Filtration Units: Three multi-vessel sand filter units will provide the primary treatment mechanism for the CESF unit. Chitosan-agglomerated particles that are suspended in stormwater passing through the filter beds are held in the sand matrix. Each sand filter unit has four 54-inch-diameter steel sand filter vessels (also referred to as a 54x4 system by the manufacturer, Yardney) with automatic backflush capabilities. As particulates accumulate in the sand media, there is an increase in pressure differential across the sand bed. In order to rejuvenate the filter media in a given vessel, the bed is temporarily fluidized as water is pumped up through the sand from below. The entrapped particles are freed from the sand matrix and flow out of the top of the filter vessel. Water for backflushing is taken directly from the filtered effluent from the other vessels in the unit, so no potable water connection is necessary. Backflush water is conveyed to the backflush settling tank.

Backflush Controls: Backflushing of the sand filters is controlled both by a differential pressure setpoint (pressure differential increases as the filter accumulates solids) and by an operational timer (to ensure a minimum backflushing frequency). The current differential pressure setpoint to trigger backflushing is 12 pounds per square inch (psi), and the operational time that will trigger backflushing is 3 hours. The minimum backflush cycle time may be adjusted up to 8 hours, based on performance at system startup. Backflushing will occur if either of these setpoints is triggered. The four sand filter vessels in a unit are backflushed sequentially. Backflushing will occur at only one sand filter vessel and one multi-vessel unit at a time to minimize flow through the Backflush Settling Tank and to prevent overloading the Inlet Weir Tank.

Backflush Settling Tank: Turbid backflush water is routed to an approximately 18,000-gallon weir settling tank (Backflush Settling Tank) to allow sedimentation of particles removed from the sand filters during backflushing. Because backflushing is limited to one sand filter vessel and one multi-vessel unit at a time, flow through the Backflush Settling Tank will be limited to approximately 239 gpm. Stormwater from the Backflush Settling Tank will gravity-flow through an overflow port and into the Inlet Weir Tanks.

Programmable Logic Controller: Three Programmable Logic Controllers (PLCs) will be used to monitor and operate the automatic features of the treatment system. The PLCs will collect and store system operational data such as pressure, flow rate, current, water levels in the system tanks, and temperature, and will initiate or control operational units based on programmed setpoints for these data. One PLC will control pumps P-310A, B, and C and the backflush cycles; one PLC will control the VFD for pump P-301; and one PLC will control the pumps and alarms associated with MH130A and OWS421.

Interconnecting Piping: Piping within the LTST system is primarily polyvinyl chloride (PVC) piping with some polyethylene tubing for sampling conveyance (i.e., for the turbidity and pH meters). System piping is above ground in the treatment area, which is outside of vehicle and pedestrian traffic areas. Exposed PVC piping will be coated with a two-part epoxy finish to protect the piping from ultraviolet (UV) light from sun exposure.

Pipe Fittings: Various pipe connection fittings are used throughout the system. Most fittings are PVC to PVC connections, made with couplers and glue. Ductile-iron to PVC or high-density polyethylene (HDPE) to PVC connections are made with bolted flanges with gaskets. To protect the piping network from damage due to differential movement of process equipment, flexible flanged connections (designed to accommodate shifting and relieve stress at pipe joints) will be used in select locations. Around flow meters or inline sampling filters, unions or flanges will be used to facilitate equipment servicing.

Effluent Water Quality Monitoring Equipment: The CESF system continuously self-monitors pH and turbidity of the treated effluent water. The monitoring system includes a pH meter, turbidimeters, flow meters, an instrument display panel, and sample collection lines. Data collected are recorded by the PLC.

Manual Valves: Manual valves are available to be used by the operator to control flow rates and internal system pressures, in the event that VFD pump control is not adequate to maintain system design parameters. There are manual valves located on the effluent side of the sand filter units. There is also a valve on the final CESF system discharge line that can be throttled as necessary to allow an adequate flow rate through the effluent bag filter.

Automatic Valves: Automated pneumatic valves are located on the effluent lines in the monitoring and control unit. These valves divert flow between the discharge and recirculation lines based on the real-time data collected with the effluent water quality monitoring equipment. If treated stormwater does not yet meet setpoint tolerances for pH and turbidity, the water is automatically routed back to the Storage Tanks for another pass through the treatment system.

Laboratory Equipment: Components for bench scale testing and monitoring include hand-held meters, beakers, droppers, filters, standard solutions, chemicals, monitoring forms, and other miscellaneous items.

Air Compressor: The air compressor provides pressurized air to operate pneumatic control valves on the CESF effluent lines and backflush valves on the sand filter units.

2.0 TREATMENT SYSTEM OPERATION, MAINTENANCE, AND MONITORING

This section describes the operation, maintenance, and monitoring of the LTST system. Performance monitoring of the system and at the point of compliance to characterize and document site-wide stormwater discharge is discussed in Section 3.0 and in the Sampling and Analysis Plan (SAP) that is provided in Appendix C of the *100% Design, Long-Term Stormwater Treatment, North Boeing Field, Seattle, Washington* (Design Report).

2.1 OPERATION AND MAINTENANCE

General operations and maintenance guidelines are provided in the Clear Water Compliance Services Operations and Maintenance Manual, provided as Attachment 1. The procedures and guidelines discussed in that operations and maintenance manual are written for CESF systems installed at construction sites. Those more typical systems generally run during regular business hours, can be constantly monitored, and include a retention structure that can detain stormwater during hours of system shutdown.

CESF systems are most frequently operated at construction sites where very turbid water (on the order of thousands of NTUs) is being treated, are operated intermittently, and are actively operated by trained personnel. Operation at NBF will differ in that treatment will take place 24 hours a day to treat base flow and storm flow (although this may use only one of the three sand filters, allowing equipment maintenance to occur on a non-rush basis during dry weather), treating stormwater with influent turbidity typically less than 25 NTU. Therefore, similar to the STST system, once the system is determined to be operating properly, operation and monitoring will be automated, leaving only weekly calibration and a routine inspection to be conducted by trained CESF operators. A remote messaging alarm system will alert personnel if additional unscheduled/immediate maintenance is needed.

Monitoring of the CESF system during operation will include residual chitosan testing, routine inspections, and sensor and chitosan metering pump calibrations. Once the CESF system is optimized and operating smoothly, the chitosan dosing rate is anticipated to remain constant, and a twice-monthly residual chitosan testing frequency is anticipated to be adequate to verify that no chitosan is being discharged to Slip 4. The monitoring frequency is also listed in the SAP (Appendix C of the Design Report); this proposed residual chitosan monitoring is a slight decrease in frequency from what was specified for the STST system, as residual chitosan has never been detected in 8 months of weekly samples of effluent from the STST facility, and there is extremely low probability of chitosan being able to pass through the sand filters.

Breakthrough of PCBs through the sand filter media at very low levels was seen at the STST system after 6 months of operation and after the four-vessel sand filter unit had filtered more than 20 million gallons of stormwater. Therefore, special attention will be paid to each of the three sand filter units as they approach or pass the point of having filtered 20 million gallons. Sand filters will also lose some of their sand during the backflush cycles, so it is planned to open up the sand filters after every 5 million gallons filtered to see if replacement sand is necessary to bring the filter media bed back up to its full height.

Table 1 summarizes the monitoring tasks associated with the treatment system and their frequency. The following sections describe startup procedures, monitoring procedures, and frequency of monitoring for the LTST system at NBF.

2.1.1 SYSTEM STARTUP

The typical operational sequences for starting and stopping the CESF system are given in Section 3.2 of the *Operation and Maintenance Manual for Chitosan-Enhanced Sand Filtration System* provided by Clear Water Compliance Services, provided as Attachment 1 to this manual for reference. These procedures are written assuming the system is shut down at the end of every shift, which does not apply to the NBF LTST system. Since the NBF system will be automated, these procedures will be required only on initial startup, and after an unexpected shutdown. A revised procedure for startup is provided below.

1. Perform site and system inspection procedures (Section 2.1.5). Unlock container and power up the system. Orient all valves for operation in recirculation mode.
2. Turn on the sensors. Read and record system volume totalizers in the Daily System Operation and Maintenance Log. Record any other relevant system information.
3. Calibrate hand-held pH, turbidity, and conductivity meters.
4. If water quality or system changes have been made, take a grab sample from the influent to the pretreatment tank and perform a bench scale treatability test to determine likely chitosan dosage.
5. Calibrate inline pH and turbidity meters.
6. Switch PLC to recirculation mode. Recheck manual valve orientation.
7. Start the filtration system pumps using the system PLC screen and watch for proper system functioning.
8. Start chitosan metering (also known by pump manufacturer name, LMI) pumps.
9. Calibrate LMI pumps to deliver proper chitosan dosage.
10. Once LMI pumps are calibrated and all discharge conditions are met, switch system to automatic mode by touching the “valves auto” button on the main screen of the system PLC.
11. Collect samples of sand filter effluent and perform the residual chitosan test.

12. Treatment technicians will remain onsite during startup to monitor overall system performance. System pressure and inline water quality results are to be recorded manually every 15 minutes in the appropriate field log, until the system has stabilized. When unmanned, the control system will automatically record water quality data every 15 minutes.
13. Residual chitosan tests are to be performed twice during the first 2 hours of system startup, then daily for the first week of operation, and as needed afterwards, but no less than twice monthly for the duration of system operation. If chitosan is detected in the system effluent, testing will revert to daily until 1 week of negative results is achieved. Chitosan dosage pump calibrations are to be performed within the first 4 hours during initial startup, and as needed afterwards, but no less than once per week for the duration of system operation.

2.1.2 System Shutdown

The NBF system will not be shut down regularly during its operational lifetime, but only for troubleshooting due to an unexpected problem. The shutdown procedures can be found in Clear Water's Manual (Attachment 1).

2.1.3 Freeze Protection

During cold weather conditions, certain precautions need to be taken to protect against freeze events. A freeze event could result in system component damage and/or operations loss. Standard operational procedures for the system will be to provide enough flow through system equipment and pipes to protect against freezing. These procedures can be found in Clear Water's Manual (Attachment 1).

2.1.4 Routine Site and System Inspection

Following the startup and frequent inspections during the first few weeks of CESF system operation, routine inspections will be conducted on a weekly basis during operation of the system. A preliminary assessment will be made of the overall integrity of a job site upon arrival. Conditions may have changed at the site in such a way that affects treatment operations. The following procedures have been adapted from Clear Water's Manual (Attachment 1):

Security: All Clear Water treatment containers are kept locked when Clear Water or other trained personnel are not present. Keys for all treatment containers will be provided by the project manager. Verify that the system is secure.

MH130A and MH130B: Check the structures for signs of proper system operation. Check the float switch in MH130A for proper operation and activation levels. Stormwater should not be overtopping the weir in MH130B except during significant precipitation events. Check that the system is pumping properly out of MH130A and discharging properly into the Inlet Weir Tank.

Chitosan Injection System Valves: Ensure that the chitosan storage tank valve is open for proper chitosan injection.

Sand Filter Bleeder and Drain Valves: Ensure the small bleeder valves at the top of the sand filter vessels and drain valves are closed.

Sample Port Valves: Ensure the water quality sampling valves are open.

Air Compressor: Make sure the compressor breaker switch is on. Check to make sure the drain valve is closed.

Pipe Integrity: Check to see if all the aboveground conveyance lines are in working order. Surface pipes at industrial sites are vulnerable to vehicle impact and environmental wear. Small stress cracks can become significant safety or operational problems when operating under pressure.

Chitosan Volume: Assess the quantity of chitosan in the storage tanks. Site project managers need to be kept aware of chitosan levels so they can schedule a timely resupply.

System Operating Pressures: Check pressures at all pressure gauges to ensure normal operation. If pressures are out of range, evaluate the status of downstream valves and filters and rectify the situation causing high pressures. After valve adjustments, filter cleaning, or filter backflush, re-check operational pressures to ensure the system is functioning within design range.

2.1.5 FIELD DOCUMENTATION

A series of triplicate forms are provided in all the system containers for Clear Water technicians to log the results of operational activities. All the forms have a field to record the project title, project number, project location, and date in the header block. System operators should print and sign their name at the bottom of the sheet. If multiple operators are working in a single system monitoring and control unit, the forms should be signed by the most senior operator. All fields on each form are to be completed. Fields that do not apply to a particular site or system should be completed with the letters NA (not applicable). Blank copies of each of the following forms are provided in Attachment 2 of this manual:

CESF – Daily System Operations and Maintenance: This is the primary form used by Clear Water operators. The pre- and post-treatment flow totalizer numbers, as well as the total volume treated and the total volume discharged, are recorded here. This form is intended to summarize system activities and productivity. Regulatory agencies require an evaluation of system performance and water quality monitoring for all discharge periods. Other relevant operational information should be recorded here for reference by Clear Water staff.

Bench Scale Treatability Form: This form is used to record water quality data and the observed results associated with the startup bench scale treatability test. The procedure for this test is described in Section 2.1.7. Visual observations shall be recorded in conjunction with each dose adjustment. Additionally, a general assessment of the entire test shall be recorded upon completion of the test.

Chemical Metering Pump Calibration Form: This form is used to record the chemical delivery pump rate and calculate the treatment system chitosan dose rate. The chitosan calibration procedure is described in Section 2.1.9.

Residual Chitosan Test Form: This form is used to record the results and sample data associated with residual chitosan tests. The procedure for this test is described in Section 2.2.2. Operating conditions that necessitate elevated chitosan dose rates may increase the residual chitosan testing requirements.

Manual Data Collection Form: This form is used to record inline water quality data (pH, turbidity) as well as system pressure. Influent and effluent data will be recorded for each of these categories. These data will be recorded every 15 minutes when checking the system, until stabilization of parameters is observed. These data should be read from the "water" page of the PLC. In addition, meter confidence checks will be recorded on this form.

Instrument Calibration Report Form: Clear Water's CESF systems have multiple water quality meters that need to be calibrated regularly. There are separate forms associated with inline pH meters, inline turbidity meters, and all the hand-held meters. There are fields to record the strength of the calibration standard used, the initial meter reading, and the calibrated meter reading.

2.1.6 SENSOR CALIBRATION AND CARE

The system's internal water quality sensors, as well as the hand-held sensors, will be calibrated weekly. Calibration information for each instrument will be logged on the accompanying calibration form. Regular calibration of the sensors will help ensure accuracy of water quality monitoring.

Confidence Checks must be performed to confirm sensor accuracy. Hand-held meter readings will be checked against inline readings during the residual chitosan tests. Confidence Checks are to be recorded on the Manual Data Collection Form.

The manufacturer-provided calibration procedures for each meter are included in Clear Water's Manual (Attachment 1). Additionally, the entire owner's manuals for the hand-held meters are included in the monitoring and control unit. Calibration standards for the inline and hand-held turbidimeters are included in the corresponding meter kits. Calibration standards for the inline and hand-held pH meters, and for the conductivity meter, are supplied in the monitoring and control unit.

Hand-Held pH Meter: It is important to properly care for the pH meter probe. Irreparable damage to the probe commonly occurs due to simple neglect. The pH probe storage solution and cleaning solution is included in the treatment system containers. Use the cleaning solution periodically or whenever its use appears necessary. Store the probe in probe storage solution whenever the meter is not in use. The tip of the probe should never be allowed to dry out. The probe will be rinsed with water between insertions into different standards or samples to avoid contamination.

Hand-Held Turbidimeter: The included cuvettes for calibration standards and sample measurements need to be handled carefully. The readability of the glass cuvettes will be compromised if they get scratched. Avoid touching the cuvettes with your bare fingers and carefully remove smudges with laboratory wipes. The cuvettes can become stained if dirty samples are allowed to sit inside for an extended period. Always promptly empty samples and rinse the cuvettes with distilled water after use. Clean stained cuvettes with a gentle solvent. Make sure the outside of the cuvettes are dry before inserting them into the meters. Introducing moisture into the meters will compromise the sample reading and damage the meter. Record the Initial Reading before calibrating the meter. Record the Final Reading after calibrating the meter.

Inline pH Meter: Follow the probe care and usage instructions previously stated for the hand-held meter. Calibrate the pH meter using the EASYCAL method identified by the manufacturer. Choose a calibration slope appropriate to the stormwater that will be treated (7 to 4 if water is under a pH of 7; 7 to 10 if water is over a pH of 7). Finish the calibration procedure by measuring the calibrated reading of the pH 7 buffer. This will ensure the meter is reading within the range of the stormwater being treated. Record the Initial Reading when the meter is in calibration mode and record the final reading when the meter is back in normal operation mode.

Carefully remove and replace probe from probe seat. Probe-amplifier lock points can be damaged if not removed gently. Cross threading is a common problem with the pH seats. Be aware of the O-ring gasket falling out when removing probe from pH seat.

Inline Turbidimeter: Follow the cuvette care and usage instructions previously stated for the hand-held meter. Be aware of condensation on the flow through cuvette. Cold water in the cuvette and the warm air inside the treatment container will often promote condensation, which would need to be wiped off before returning the cuvette to the measurement chamber. Record the Initial Reading and Final Reading when in calibration mode.

2.1.7 BENCH SCALE TREATABILITY TEST

After the water quality sensors have been calibrated, the system operator can perform the bench scale treatability test at system startup. This test will be conducted during the initial system startup testing and will be used to assess the conditions of the stormwater to be treated and to determine the proper chitosan dosage rate. Unlike a construction site, the water quality conditions of the stormwater at NBF are relatively constant. Therefore, future bench scale treatability testing will be conducted only if there is reason to believe the influent stormwater quality has changed significantly. The following description of the treatability test has been adapted from Clear Water's Manual (Attachment 1).

The bench scale treatability test lets the operator know of possible treatment problems prior to introducing water to the CESF system. Several factors can influence treatability, including concentration of suspended solids, pH, detergents, the presence of soil tackifiers such as polyacrylamides (PAMs) and guar in the runoff.

The samples procured for this test should be representative of system influent, and should not contain sediment that would settle naturally (sand and rocks). Multiple tests may be required since the LTST system will be treating stormwater from both MH130A and OWS421.

Required Equipment: In order to perform this testing sequence, the following items are required:

- Properly calibrated pH meter
- Properly calibrated turbidimeter
- Properly calibrated conductivity meter
- One 1-liter sample glass beaker

- One 1-liter sample plastic beaker
- Chitosan acetate
- Pipette
- Stir rod.

Perform the Screening Test:

1. Retrieve a 1-liter grab sample of stormwater from the influent with a plastic beaker.
2. Transfer the sample into a 1-liter glass beaker.
3. Measure and record initial pH, conductivity, and turbidity of sample in the appropriate field log.
4. If the sample does not have a pH reading conducive to treatment (6.5 to 8.0), carefully adjust the pH of the sample by adding small amounts of sodium bicarbonate or acetic acid until the sample reads a pH close to 7. Record the adjusted pH and note treatment method.
5. Add one drop of a known quantity chitosan to the sample.
6. Stir sample vigorously for 1 minute to assure dissolution.
7. Allow sufficient settling time and observe solution for the formation of small floc particles called pinfloc.
8. Grab a sample from the surface of the sample jar and record the turbidity.
9. Repeat steps 5 through 8, recording observations and dosage related to the appearance of floc and settling.

Interpreting the Screening Test: Visible sediment settling indicates that chitosan has coagulated the particles. The beaker may contain clear water on top, or be slightly cloudy, and there should be variation in coagulation amount between dose rates. The object of this test is not to produce completely clean, clear water in the beaker. Rather, it is to determine the most suitable dose rate for CESF treatment. For planning purposes, the smallest effective dosage will be used as the initial dose rate. If there is no change in sample appearance (i.e., reduction in turbidity) between doses, it is assumed that there are treatability problems. This is rare, and may occur for different reasons that need to be investigated.

2.1.8 pH ADJUSTMENT

Adjustment of pH may be required based on some site conditions for regulatory and operational purposes. Many aquatic species are very sensitive to pH alterations and even a small alteration can have a significant effect on a natural system. Information on pH adjustment, based on observed NBF site conditions and adapted from Clear Water's Manual (Attachment 1), is provided below for reference.

Relatively low pH stormwater (6.0 to 6.5 standard units) has been observed onsite at NBF during heavy rainfall events. In accordance with the Industrial Stormwater General Permit issued to the facility by Ecology, water from the facility can be discharged within a pH range of 5.0 to 9.0. The CESF treatment system has been set to automatically go into recirculation mode and not discharge treated stormwater if pH goes outside of the operational control range of 5.5 to 8.5 standard units. This control will help to ensure that treated and discharged stormwater is well inside the pH benchmark range of the permit.

Although chitosan is expected to be most effective within a pH range of 6.5 to 8.5 standard units, the LTST CESF system is expected to meet the treatment goal of 95 percent or greater removal of suspended solids [or a maximum concentration of 1 milligram per liter (mg/L) when influent total suspended solids (TSS) is less than 20 mg/L] over a wider pH range, as was typically observed at the STST system. Because of that expectation and the observation that stormwater pH is rarely outside the pH range of 6.6 to 8.5, adjustment of pH is not planned for operation at NBF. However, if it is found that the treatment performance goal for removal of suspended solids is not met due to pH issues (which is not expected), pH adjustment will be performed. The adjustment of pH for CESF systems is generally done with one of two chemicals: sodium bicarbonate or carbon dioxide (CO_2). Sodium bicarbonate raises low pH and CO_2 lowers high pH. Care must be taken during addition of bicarbonate or carbon dioxide in order to prevent over-correction of pH.

2.1.9 Chitosan Metering Pump Calibration

The following information has been adapted from Clear Water's Manual (Attachment 1). Clear Water technicians will operate and calibrate the chemical metering system. Metering pumps are often referred to as LMI pumps because of the common use of metering pumps produced by the manufacturer of that name. Calibrations are to be performed every 4 hours during initial startup, and as needed afterwards, but no less than once per week for the duration of system operation, to ensure that the dose rate is at or below 1.0 ppm. Additionally, the metering pump shall be recalibrated when a significant change occurs in the influent turbidity. Calibration results and flow rates will be recorded on the CESF system monitoring forms and the calibration records will be kept onsite.

OPERATIONAL NOTE: Metering pump dials should be adjusted **ONLY** when pumps are **OPERATIONAL.** Adjusting pump dials while pump is not running will likely result in pump damage and/or failure.

When adjusting the metering pump to obtain the proper dose rate, there are two primary adjustments: stroke frequency and stroke length. Experience has shown that the stroke frequency should be set as high as possible for a consistent rate of delivery, and then the stroke length adjusted to deliver the desired dose rate.

The CESF chemical injection system for the LTST system has four chitosan metering pumps with a dedicated delivery line for each pump; one metering pump is used for the pretreatment dose prior to stormwater entering the Storage Tanks, and the other metering pumps are used for the final chitosan dose prior to the sand filters.

Calibration Procedure:

1. Fill the calibration cylinder by opening the valve on the bottom of the cylinder. Fill the cylinder as close to full as the static head pressure on the storage tank will allow without overfilling.
2. Close the valve on the chitosan storage tank.
3. Allow the LMI pump to drain the cylinder to a desired volume and then begin timing the pump for 1 minute.
4. Close the cylinder valve at exactly 1 minute.
5. Immediately open the valve on the chitosan storage tank.
6. Read and record the volume of chitosan consumed.
7. Calculate the dose rate using the calculation table below. Pair the chitosan consumption rate with the corresponding stormwater flow rate.
8. Convert delivery rate from milliliters per minute (mL/min) to milligrams per minute (mg/min) (multiply result by 10 for 1% chitosan) and flow rate from gallons per minute (gallons/min) to liters per minute (L/min) (multiply by 3.78). Divide chitosan delivery rate by flow rate to get dose rate (ppm). Refer to formulas presented below.
9. Adjust delivery rate toward desired dose rate* if necessary and repeat procedure until proper dosage is achieved.
10. Record the final results on the Chemical Metering Pump Calibration Form.
11. Repeat procedure for next LMI pump.

* The desired dose rate depends on many variables including site and system history, turbidity levels, use level designation limits, water chemistry, flow rate, and pre-treatment activity. Typically, an operator should dose the minimum amount necessary to achieve the desired result. The dose rate for all three metering pumps for the final chitosan dose prior to the sand filters should be the same.

Formulas:

- Liqui-Floc delivery rate (mL/min) x 0.01 (chitosan concentration) x 1 gram per milliliter (g/mL) (weight of Liquid-Floc) = absolute weight of chitosan in grams per minute (g/min)
- Chitosan delivery (g/min) x 1000 milligrams per gram (mg/g) = delivery rate (mg/min)
- System influent flow (gpm) x 3.78 liters per gallon (L/gal) = flow rate (L/min)
- Delivery rate (mg/min) / flow rate (L/min) = dose rate in milligrams per liter (mg/L) = ppm.

When the LMI calibrations are complete, verify that the valve on the chitosan storage tank is open and the valve on the calibration cylinder is closed. Verify that all LMI pumps are on. Record the dose rate of the pretreatment pump and the sand filter pumps separately. Add these two dose rates together to get the overall system dose rate (e.g., if the pretreatment pump dose is 0.2 ppm and the dose for each of the three sand filter pumps is 0.47 ppm, the overall system dose rate would be 0.67 ppm). The overall system dose rate shall not exceed the maximum allowable chitosan dose rate (1 ppm).

2.1.10 BACKFLUSH

Backflushing is the process by which water flow is reversed through the sand filter beds to expel the accumulated sediment. Each sand filter vessel is flushed one at a time while the rest of the vessels in the sand filter unit continue to operate normally. The stormwater that was filtered from the active vessels will fill the bottom header and a portion of it will be forced upward through the vessel being backflushed.

Although backflush cycles are automated, the process needs to be understood by the system operator, and periodically monitored (at least once per week) to ensure optimal backflush flows and pressures. Monitoring includes testing of the backflush mechanism and pressure differential switch. The backflush parameters will be controlled through the PLC, but can also be set from the control box, which is fixed to the side of the sand filter unit. Parameters include flush duration, delay between switching vessels, and backflush trigger setpoints for both pressure differential and time elapsed since last backflush. The setpoint for backflushing based on differential pressure will be initially set to 12 psi. Additionally, backflushing will occur once per 3 hours of operation, as controlled by the PLC. These parameters may be adjusted once CESF system performance is observed, to optimize system performance and maximize the treatment flow rate.

As the filter beds become clogged with floc particles, the pressures between the top and bottom headers begin to deviate. The top header will gain pressure and the bottom header will lose pressure due to decreased water passage. When this pressure differential reaches the setpoint of 12 psi, the system will initiate the backflush cycle to remove the captured floc from the media bed.

The system requires a minimum of 20 psi effluent pressure for adequate backflush. Pressures below this will generally not be high enough to fluidize the sand beds, which is necessary for proper backflush. System pressures and flow rates will differ between operation and backflush cycles. Operators can monitor flows and pressures during transition to backflush to assure they remain optimal. Valve adjustments may need to be made accordingly. In addition to the effluent control valves, there is a valve at the end of the backflush header. This valve is set during system startup to optimize backflush flow without discharging filter media. This backflush valve generally does not need adjusting and should be adjusted only by experienced operators who are familiar with the system.

A sight glass is installed at the top of the backflush header to monitor backflush efficiency. The water in the sight glass should appear turbid during the initial stage of each vessel flush. Toward the end of the flush, the water should appear clearer as all of the floc is expelled from the sand bed. A backflush sample line can also be used to monitor the effectiveness of the backflush. Flush duration will be set at 2 minutes. To increase backflush effectiveness, operators should increase the frequency instead of duration of the cycle.

The consequence of insufficient backflushing is impacted sand beds. Failure to backflush will cause excess floc accumulation in the filter. Excess floc under operating pressures will limit water movement through the beds. This is commonly called impaction, which is a condition that will cause system shutdown. The water in the filter must then be evacuated, the filters opened, and the sand in the filter broken up with a shovel. In extreme cases, the filter medium may be so compromised that it will need to be discarded and replaced. With the low TSS concentrations at NBF, this condition was not experienced at the STST system and is not expected to occur at the LTST system.

Backflush water is discharged to the Backflush Settling Tank where the solids can settle out. Stormwater from the Backflush Settling Tank will gravity-flow through an overflow port and into the Inlet Weir Tanks. Procedures for monitoring and removal of accumulated solids from the Backflush Settling Tank are discussed in the following section.

2.1.11 MONITORING AND REMOVAL OF ACCUMULATED SOLIDS

Any wastes from operation and maintenance of the LTST facility will be tested and profiled to determine contaminant concentrations and disposal requirements. Based on relatively low TSS concentrations in NBF stormwater, the Inlet Weir Tank is not anticipated to accumulate an amount of solids during system operation that would require frequent cleanout of solids. The solids level in the Inlet Weir Tank, each Storage Tank, and the Backflush Settling Tank will be inspected at least once per month. For the Inlet Weir Tank and the Storage Tanks, if the solids level at the bottom of the tank is greater than 12 inches, a sample of the solids will be collected for waste profiling purposes and the solids will be cleaned out from the tank.

The flow rate through the Backflush Settling Tank will be low enough that re-entrainment of solids is less likely than at the other tanks, and a deeper blanket of solids could accumulate without negative effects. Additionally, a deeper blanket of solids may allow for sludge thickening, which would limit the amount of liquid that would need to be removed and disposed of during tank cleanout.

Therefore, the depth of solids in the Backflush Settling Tank may be allowed to reach up to 24 inches prior to waste profiling and cleanout.

Monitoring of accumulated solids will be performed with a Sludge Judge® or similar device inserted from the top of the tank to the tank floor. The device collects a sample that can be retrieved and visually inspected. The thickness of accumulated solids in the sampler is observed and recorded. An average of four or more readings, spread approximately equally along the length of the tank (for the weir tanks, the four readings will be taken between the weir and the inlet end of the tank) will be used to determine if the solids level exceeds the aforementioned depths, and requires solids testing and tank cleanout.

The allowable depth of sludge blanket in each tank may be adjusted if monitoring suggests that the optimum sludge blanket depth is greater or less than the aforementioned depths. For example, if turbidity monitoring shows enhanced flocculation at the Inlet Weir Tank due a depth of solids greater than 12 inches, the depth at which cleanout is triggered may be modified.

2.2 SYSTEM MONITORING

This section describes the residual chitosan sampling procedure, the remote alert messaging system, and system bypass observation and documentation procedures.

2.2.1 CHITOSAN MONITORING

High doses of chitosan in the aquatic environment have exhibited toxic effects on fish in laboratory tests. Therefore, the system will be operated in a manner that prevents chitosan discharges to Slip 4. In the CESF process, the majority of the chitosan introduced into stormwater is removed along with associated solids during the coagulation/flocculation process and subsequent settling and filtration. Monitoring will be conducted to evaluate system performance in regards to limiting residual chitosan concentrations in CESF system effluent.

The residual chitosan test is used as a precautionary measure to alert technicians of potential treatment problems before significant impacts can occur. Boeing has discussed the use of CESF at NBF with Ecology. Ecology has stated that CESF is an approved water treatment process for construction projects and, although the NBF site is not a construction project, it does not object to the use of CESF at NBF. Ecology has issued a General Use Level Designation (GULD) for the use of CESF systems for stormwater discharges at construction sites (Ecology 2008). Although NBF is not a construction site, many of the conditions from this document, as discussed below, are applicable to the LTST system, unless otherwise noted.

- Formal written approval from Ecology is required for the use of chemical treatment at each site. Written approval must be obtained from the appropriate Ecology regional office. This approval applies only to discharges to surface waters.
  - For the STST system at NBF, application forms for stormwater treatment have been completed and submitted to Ecology. A new application form for the LTST system will also be submitted to Ecology and that form updated and resubmitted as may be necessary due to changes in system operation.
- This use level designation applies only to ChitoVan™/SeaVan™ (1 percent chitosan acetate solution).
- The chitosan dose rate for water entering the filters shall not exceed 1 mg/L ChitoVan/SeaVan (as chitosan by weight). All calibration results must be recorded simultaneously with the flow rates and kept onsite.
- Source control procedures shall be implemented to the maximum extent feasible to minimize the need for the use of additional chitosan acetate for the pretreatment of stormwater. Additional ChitoVan/SeaVan (amounts greater than 1 mg/L chitosan by weight) may be used to pretreat water that exceeds 600 NTU. A portion of the 1 mg/L ChitoVan/SeaVan may be used to pretreat water less than or equal to 600 NTU. Pretreatment must occur in a tank or basin dedicated to pretreatment. All pretreated water must enter the sand filters. Pretreated water must have no less than 50 NTU and no more than 600 NTU before final dosing. This will help ensure that free chitosan does not enter the CESF system. Also, 1 mg/L ChitoVan/SeaVan (chitosan by weight) is sufficient to treat water in this range. Water exiting the pretreatment tanks must be continuously monitored for turbidity. An automatic integrated turbidity sensor shall be located on the output from the pretreatment tanks or basins. This sensor will alert the operator when turbidity values fall outside of the 50 to 600 NTU range. If this occurs, operators can reroute the out-of-spec water to the untreated stormwater pond, shut the system down, or conduct additional residual chitosan tests. One of these actions must occur each time the alarm goes off. Jar tests must be used to determine proper pretreatment dosing and proper treatment dosing.
  - Stormwater at NBF has a much lower turbidity than stormwater at construction sites, and has consistently been measured to be less than 50 NTU. In addition, the NBF project has a much lower effluent TSS/turbidity requirement than for a typical construction site. Therefore, the procedures outlined above are not considered applicable for the NBF project, but other adequate precautions are taken to ensure that chitosan is not overdosed and that there is no detectable residual chitosan in the sand filter effluent.
- Jar tests are to be conducted at startup to determine the dosage level of chitosan acetate solution. Jar test results are to be recorded in the daily operating log. If the results of the jar test indicate that the dose needs to be adjusted, the jar testing results and the indicated dose rate change shall be documented in the daily operating log.
  - Bench scale treatability tests will be conducted for LTST system operation to determine the dosage level of chitosan acetate solution for stormwater at NBF, as described in Section 2.1.7.
- During CESF operation, water quality influent and effluent shall be continuously monitored for pH, turbidity, and flow. For batch treatment systems, only water discharged from the batch treatment basins or tanks must be continuously monitored for pH, turbidity, and flow during discharge.

- The discharge flow rate shall be continuously metered and recorded. For batch treatment systems only, water discharged from the batch treatment basins or tanks must be continuously monitored for flow rate.

- The effluent shall be monitored for residual chitosan or aquatic toxicity. If effluent will be monitored for aquatic toxicity, the most sensitive test reported in the intended use plan must be used. If the effluent will be monitored for residual chitosan, a discrete grab sample of homogeneous sand filter discharge must be collected and analyzed within 30 minutes of the onset of operation and 2 hours after startup to confirm a discharge concentration below 0.2 ppm. The test is to be repeated whenever there is a change in dosage, or a significant change in influent turbidity or flow rate. For batch treatment systems, only water discharged from the batch treatment basins or tanks must be monitored. For batch treatment systems, an additional grab sample of the potential batch treatment discharge must be collected and analyzed for aquatic toxicity or residual chitosan before any discharge from treatment basins or tanks can occur.

  – The NBF system will be operated on a continuous basis and, therefore, will not have periodic startup similar to construction sites. When the system is started up, two grab samples will be collected and analyzed as described above. After the system is automated, it will be monitored for residual chitosan as described in Section 2.2.2.

- Discharges from the CESF shall be maintained below 0.2 ppm residual chitosan at all times. Discharges must be monitored for residual chitosan or aquatic toxicity. In the event that the chitosan residual in the discharge is greater than 0.2 ppm, the discharge exhibits aquatic toxicity, or when the CESF system fails to meet discharge quality requirements, a contingency plan must be included in every stormwater pollution prevention plan (SWPPP) that immediately corrects the situation. The operation and maintenance manual must include contingency plan measures and must be available onsite.

  – Residual chitosan testing procedures are provided in Section 2.2.2, along with a discussion of contingency actions if residual chitosan is detected and confirmed above 0.2 ppm.

- Discharges from the CESF system shall not cause or contribute to receiving water quality violations and shall comply with all known, available, and reasonable treatments (AKART) and local government requirements for turbidity and other applicable pollutants.

  – Stormwater discharge at NBF is permitted through the Industrial Stormwater General Permit. The interim goal for PCBs in treated stormwater is 0.030 micrograms per liter (μg/L).

- Discharges from the CESF system under these designations shall achieve performance goals of a maximum instantaneous discharge of 10 NTU turbidity and a discharge pH within a range of 6.5 to 8.5. These limits reduce interferences associated with the residual chitosan test.

- Discharges from the CESF system at NBF will be controlled to below 10 NTU and are generally within the pH range of 6.5 to 8.5. See Section 2.1.8 for a discussion of the expanded pH range applicable during the limited period of extreme rainfall events.

- The CESF facility contractor shall guarantee that the CESF system, when used as directed, will not produce treated water that exhibits aquatic toxicity caused by chitosan added as a treatment agent.

- The CESF system shall be operated only by a trained technician certified through an Ecology-approved training program that includes classroom and field instruction. The technician must have the following minimum training requirements:
  - Prerequisites:
    - Fundamental knowledge of high-pressure sand filter systems
    - Fundamental knowledge of water pumping and piping systems
    - Fundamental knowledge of stormwater discharge regulations for applicable region/locale
    - Fundamental knowledge of stormwater quality testing procedures and methods for parameters applicable to the region/locale.
  - Classroom (8 hours)
    - Stormwater regulatory framework and requirements
    - Stormwater treatment chemistry (chitosan, pH, coagulation, filtration, etc.)
    - Stormwater treatability (how to do jar testing)
    - Treatment system components and their operation
    - Treatment system operation
    - Troubleshooting.
  - In the field (32 hours)
    - Operating the treatment system
    - Entering data in the system operations log
    - Testing turbidity and pH
    - Optimizing chitosan dose rate
    - Water quality sampling and testing (turbidity and pH)
    - Residual Chitosan Test.
- The SWPPP is to include a field procedure, accepted by Ecology, for *detecting residual chitosan in stormwater discharges sensitive to 0.2 ppm.*
  - Procedures for residual chitosan detection are provided in Section 2.2.2 below.

2.2.2 RESIDUAL CHITOSAN TEST

The treatment system will be operated in accordance with applicable local, state, and federal regulations and standards. At the STST system, residual chitosan testing was initially performed daily during routine system monitoring. After discussions with the EPA, residual chitosan testing is currently performed weekly to verify that no dissolved chitosan is making it past the sand filter system, as no residual chitosan has been detected in 8 months of STST system operation. Based on successful operation at the STST, detection of residual chitosan from the LTST system is not likely.

The chemical composition of chitosan is such that it binds to the anionic solids as well as other chitosan molecules within the top layers of the sand filter media rather than going through the filter in a dissolved form, making the presence of residual chitosan (>1 mg/L) in treatment system effluent nearly impossible. It should be noted that Clear Water has performed controlled pilot tests and experiments in which influent dose rates of up to 50 mg/L have not yielded a positive residual chitosan test. Residual chitosan testing at the LTST system will be conducted twice during initial startup, then daily for the first week of operation. If the results are negative for residual chitosan, then testing will be performed twice monthly for the duration of system operation. If a positive result is received at any time during system operation, testing will revert to a daily frequency until 1 week of consecutive negative results is achieved. Additional testing will also be performed whenever the dose rate or turbidity changes significantly. The following procedure, taken from Clear Water's Manual (Attachment 1), was produced as a quick reference for Clear Water technicians with considerations given to company-specific equipment.

Required Equipment: There should be two separate, clearly marked, sets of equipment. One set will be used for the sample analysis and should be marked "sample." The second set will be for the matrix spike used for a color comparison. The second set should be marked "spike." Equipment includes:

- Two stir rods
- Two 140 mL capacity plastic syringes with threaded tip
- Two threaded plastic Swinnex filter seats
- Two plastic 1L beakers
- One pair of forceps
- Plastic disposable droppers
- Fiberglass micro filters
- Chemicals: 1 percent chitosan acetate, 0.1N solution Iodine, Sodium Bicarbonate (with scoop).

Procedure: Make sure all equipment is washed thoroughly and proper laboratory procedures are followed. Most "hits" produced in this test are actually false positives that are due to contaminated equipment.

1. Take two separate 1-liter samples from the sand filter effluent sample line.
2. Measure and record pH, turbidity, and conductivity on the Residual Chitosan Test Monitoring Form. Transfer all relevant data from the LMI calibration to this form.
3. Add two drops of 1 percent chitosan acetate to the beaker marked "spike." Stir vigorously for 1 minute to assure dissolution. This beaker now has a chitosan concentration of approximately 0.2 ppm.

4. Add one scoop (approximately 5 grams) each of sodium bicarbonate to the sample and the 0.1 ppm spike sample. Stir vigorously for 1 minute. Read and record the adjusted pH. The new pH level must be at 8 or above to cause the chitosan to come out of solution.
5. Open the Swinnex filter seats and carefully place clean filter papers in each one with a pair of forceps. Carefully thread the seats back together. Avoid cross-threading the seats for proper filter dosing.
6. Draw 100 mL of the treated sample water from the "sample" beaker into the "sample" syringe. Thread the "sample" filter seat onto the syringe. Slowly push the sample water through the filter. Repeat with another 100 mL (200 mL total). Repeat procedure with "spike" sample.
7. Remove the filter seat from the syringe and then remove the filter from the seat with forceps. Remove the sample first and the spike second to avoid contamination.
8. Place each filter on a clean, inverted glass beaker to dry. Place the beaker a reasonable distance in front of a space heater to facilitate drying. Dry completely for optimum results.
9. After the filters are dry, add one drop of iodine to each filter. Wait 15 minutes to interpret results.
10. A light yellow rust color indicates the absence of chitosan. This is how the sample should appear. A dark brown or blue/black color indicates the presence of chitosan. This is how the spike sample should appear.

If an operator gets a positive test, the system will immediately be shut down and investigated to determine if any of the operating parameters are out of specification. The system can then be corrected and the filtrate re-tested to confirm the absence of chitosan in the treated filtrate. If chitosan above 0.2 ppm in the treated filtrate is confirmed, the sand filter media will be replaced.

2.2.3 Remote Alert Messaging System

In addition to daily monitoring conducted onsite by a technician as described in Section 2.1, the treatment system at NBF will incorporate a remote alert messaging system that will send text messages to Clear Water staff, enabling them to remotely monitor the status of the treatment system. These messages can alert a technician to situations that may require an unanticipated site visit to investigate the potential problem. The situations that will send a text message to Clear Water staff include:

- High "Pond" Alarm – indicates a high level in the Inlet Weir Tank
- High Tank Alarm – indicates a high level in the Storage Tanks
- Backflush – indicates a backflush cycle is taking place
- Recirculation – indicates a recirculation event is taking place
- High Effluent Turbidity
- High Influent Turbidity
- High and Low pH
- High and Low Pressure (system)

- High and Low Pressure (air compressor)
- Pump Faults
- Power Failure
- Excessive Backflush.

2.2.4 TREATMENT BYPASS

Treatment system sizing is discussed in the Design Report. To assess the amount of stormwater treated and the amount of bypass from the preferentially-treated North Lateral at NBF, the water level datalogger (pressure transducer) installed upstream of the weir in MH130B on September 22, 2010 will continue to record water levels. The transducer collects a water level reading every 30 seconds. The water level readings will be compared to the weir elevation to determine the time and duration of overflow events and to estimate the volume of stormwater bypassing the treatment system. The pressure transducer will be calibrated quarterly to ensure continued accuracy and replacement of the desiccant on the vent tubing will be performed approximately every 4 months (based on visual color change of the desiccant media) to prevent moisture damage to the transducer.

Boeing will continue to report operational data (e.g., total gallons of stormwater treated, rainfall data, and any unusual events) on a monthly basis in progress reports submitted to EPA by the fifth day of each month. Those monthly progress reports will include the calculated estimate of the volume of stormwater from MH130B that bypassed the CESF system in the previous month.

2.2.5 SPILL PREVENTION AND CONTINGENCY

Several engineering controls will be put in place to prevent stormwater from overflowing the system and discharging to ground surface. It should be noted that while these measures are considered appropriate and important to the system design, spills of water to the ground surface are not catastrophic in nature. The following system controls prevent overflows or spills of stormwater:

- High level alarms increase pumping flow rates to empty the tank.
- High-High level alarms will shut off pumps at MH130A and LS431 and dial-out alarm conditions to system operators.
- Tanks are outfitted with overflow ports that connect to the lift station, acting as a natural bypass if the system is inundated and some malfunction in the system and high-high level alarm condition shutoff. These overflow ports are the third layer of defense to prevent overflowing the stormwater to the ground surface. Flow rates of stormwater through the system could conceivably reach a maximum of 1,739 gpm (1,500 gpm design pumping flow from MH130A and LS431, and potentially the 239 gpm backflush flow from the sand filters). Tank overflows are design to accommodate this discharge directly to the lift station.
- To protect system piping, flexible flanged fittings are installed in each piping run near process equipment or the system influent connections (above ground).

- Regular system monitoring, inspection of process equipment, and review and documentation of operational parameters is the most effective way to proactively prevent spills. Operators inspecting equipment or responding to system dial-outs will assess system integrity and shut down the system and perform repairs if necessary.
- It is not expected that fuel of any type will be stored at the site.
- Chitosan storage is limited to two 275-gallon containers. Container integrity will be monitored closely and a spill kit will be stored nearby in case of an accidental spill.

3.0 PERFORMANCE MONITORING

A Sampling and Analysis Plan (SAP) has been developed for this system and was provided as Appendix C of the Design Report. The SAP is made up of a Field Sampling Plan (FSP) and a Quality Assurance Project Plan (QAPP). Please refer to the SAP for details regarding sampling objectives, sampling locations, sampling methodology, and quality assurance objectives and procedures. The following sections provide a brief introduction to these topics.

3.1 SAMPLING OBJECTIVES AND LOCATIONS

The objectives of field sampling are to gather data to monitor compliance with LTST interim goals, and to evaluate the performance of the LTST facility. This includes monitoring the LTST system to assess both the performance of the CESF system in removing PCBs and TSS and monitoring of NBF full-site stormwater discharges at the lift station (LS431).

To achieve these objectives, sampling will occur at the following locations:

- **Lift Station (LS431)**
  - Compliance monitoring point
  - Located downstream of the LTST system effluent discharge
  - Flow-weighted whole water and filtered solids sampling
- **LTST Facility**
  - Whole water and filtered solids sampling of influent and effluent
    - North lateral (MH130A) sampled independently from the combined influent (from the LS431 inlet vault)
  - Inlet Weir Tank, Storage Tanks, and Backflush Settling Tank
    - Thickness of solids monitored monthly
    - Solids will be sampled and characterized prior to disposal
  - Sediment traps
    - Solids collected from sediment traps SL4-T1, SL4-T2, SL4-T3, SL4-T4, SL4-T4A, SL4-T5, and SL4-T5A
    - It is expected that the City of Seattle will continue to monitor sediment traps SL4-T1A, SL4-T2A, and SL4-T3A
  - Sand filter media
    - Prior to disposal, samples will be collected from the spent sand media for characterization.

3.2 DATA QUALITY OBJECTIVES AND REPORTING

Performance monitoring must be capable of producing data of sufficient quality to evaluate PCB removal effectiveness, compliance with the interim action goals, and disposal of treatment solid wastes. Please refer to the SAP for details concerning how these data quality objectives are met and proper usage of the generated data. To confirm the general effectiveness of the LTST treatment system, TSS removal will be monitored. The STST system had requirements to consistently achieve 95 percent removal of TSS from stormwater, or, if the influent TSS was less than 20 mg/L, the system was to achieve a treated effluent TSS not to exceed 1 mg/L. It is anticipated that the LTST system will also achieve these removal efficiencies. If sample analysis shows this goal is not being met at the LTST, Boeing will make adjustments to the treatment system based on observed performance and sample data.

Until such time that EPA approves of alternate reporting requirements, Boeing will continue to prepare monthly progress reports and submit those reports to EPA by the fifth day of the following month (or the first subsequent work day if the fifth day of the month falls on a weekend or holiday). Monthly progress reports will continue to include information related to stormwater treatment system operation (i.e., total gallons of stormwater treated, rainfall data, any significant operational problems or system shutdowns) and will contain summary data tables of all validated stormwater analytical testing results that were received from the laboratory by the 24th of the month. Results of the Stage 2A data validation, as described in the SAP (Appendix C of the Design Report), will be documented in a technical memorandum. The technical memorandum will include a disk with electronic copies of chain-of-custody forms and laboratory data packages, and submitted to EPA with project monthly reports.

4.0 USE OF REPORT

This Operation and Maintenance Manual has been prepared for the exclusive use of The Boeing Company and applicable regulatory agencies for the North Boeing Field property area. No other party is entitled to rely on the information and recommendations included in this document without the express written consent of Landau Associates. Further, the reuse of information and recommendations, without review and authorization by Landau Associates, shall be at the user's sole risk. Landau Associates warrants that within the limitations of scope, schedule, and budget, our services have been provided in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions as this project. We make no other warranty, either expressed or implied.

This document has been prepared under the supervision and direction of the following key staff.

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TABLE D-1
SUMMARY OF MONITORING TASKS
CHITOSAN-ENHANCED SAND FILTRATION SYSTEM - NORTH BOEING FIELD
SEATTLE, WASHINGTON

Task	Section of O&M Manual	Frequency Required
Routine Site and System Inspection	Section 2.1.4	Minimum Once Per Week, Daily During any Non-Routine Activities
Sensor Calibration	Section 2.1.6	Weekly
Bench Scale Treatability Test	Section 2.1.7	Conducted during first week of initial startup. Also to be conducted if influent water quality changes significantly.
Chitosan Metering Pump Calibration	Section 2.1.9	Every 4 hours during initial startup, then minimum of once per week. Also whenever chitosan dosage rate is changed.
Backflush System Monitoring	Section 2.1.10	Weekly
Monitoring and Removal of Accumulated Solids	Section 2.1.11	Monthly monitoring; removal when solids accumulation meets or exceeds 12 inches (inlet weir tank or storage tank) or 24 inches (backwash settling tank).
Residual Chitosan Test	Section 2.2.1	Twice during startup, then daily for first week of operation. If all results are negative for residual chitosan, then twice monthly for the duration of system operation. If a positive result is received, testing will revert to a daily frequency until one week of consecutive negative results is achieved. Also whenever the dose rate changes or when turbidity or flow rate changes significantly.
Whole Water Sampling of System Influent/Effluent for Total PCBs and TSS	Section 3.1	See Sampling and Analysis Plan (Appendix C of LTST 100% Design Report)
Filtered Solids Sampling of System Influent/Effluent for Total PCBs and TSS	Section 3.1	See Sampling and Analysis Plan (Appendix C of LTST 100% Design Report)
Sampling at Compliance Point (Lift Station LS431)	Section 3.1	See Sampling and Analysis Plan (Appendix C of LTST 100% Design Report)
Sampling Solids from Settling Tanks and Sand Filters for Disposal Characterization	Section 3.2	See Sampling and Analysis Plan (Appendix C of LTST 100% Design Report)

ATTACHMENT 1

Clear Water Compliance Services Operation and Maintenance Manual

Clear Water Compliance Services®

OPERATION AND MAINTENANCE MANUAL

FOR

CHITOSAN-ENHANSED SAND FILTRATION SYSTEM

Clear Water Compliance Services
12314 Beverly Park Rd., Unit 134
Lynnwood, WA 98037

TABLE OF CONTENTS

INTRODUCTION

1.1 CHITOSAN-ENHANCED STORMWATER TREATMENT

This Operation and Maintenance Manual (O&M Manual) has been written to describe the elements involved in the deployment, operation and maintenance of chitosan-enhanced sand filtration systems for treating stormwater on typical construction sites.

Chitosan enhanced sand filtration (CESF) is a safe and effective method for removing sediment from stormwater runoff. Proper stormwater management protects our natural waterways and enables site development. Flow-through CESF systems can treat far greater quantities of stormwater runoff than traditional settling processes. CESF is not a substitute for traditional stormwater management techniques. This technology is to be used in conjunction with standard erosion and sediment control measures.

1.2 INTRODUCTION TO CHITOSAN

Chitosan is extracted from chitin and is nature's second most abundant natural biopolymer next to cellulose. Chitin is the structural material found in crustacean shells such as shrimp, crabs, and lobsters. Chitin is also found in fungi cell walls and the exoskeletons of insects. Chitin and chitosan are natural components of biochemical degradation processes occurring naturally in the earth's soil and water. Like chitin, chitosan is found to exist naturally in the environment (water and soil) because it is a biodegradation product of chitin.

Chitosan acetate has been used in water treatment for more then three decades. It has the unique ability to absorb dissolved oil and grease from water, chelate (bond with) heavy metals, and flocculate suspended sediment. Chitosan-based water treatment has been used for decades in various industrial and municipal applications and commercial aquarium clarification. The U.S. Environmental Protection Agency has approved chitosan for use in drinking water treatment and in the agriculture industry.

There are different chitosan acetate solutions formulated specifically to treat construction stormwater. In the State of Washington, the use designation for chitosan acetate depends on the product manufacturer, concentration, and treatment method. The body of this text will explain treatment operations for General Use Level Designation of 1% chitosan for direct discharge.

Stormwater treatment with Chitosan, at proper dose rates, is highly effective in reducing turbidity levels by greater than 95% when used with sand filtration systems. Chitosan's effectiveness lies in its ability to make small suspended soil particles larger and denser. The larger and denser floc particles can be easily removed through forced settling or sand filtration. The cationic nature of chitosan molecules interact with the predominately anionic sediment particles in stormwater. As these opposite charges attract, the chitosan molecules can bind with numerous soil particles. This process of flocculation creates larger, denser particles in solution, allowing them to settle via gravity or be removed by filtration systems. Over dosing can cause the opposite of the intended effect. An excess of cationic material can cause the floc that initially formed at a lower dose to break apart.

1.3 CESF TREATMENT OVERVIEW

Chitosan-enhanced sand filtration is a flow-through stormwater treatment technology that utilizes chitosan in conjunction with pressurized sand filtration to remove suspended sediment from stormwater runoff. These systems are designed to be deployed on construction sites for the duration of a particular development project and then removed after the successful stabilization of all disturbed areas. Construction companies are compelled by law to prevent the discharge of polluted stormwater runoff from active construction sites. Clear Water Compliance Services works in conjunction with its clients to develop and implement a comprehensive Stormwater Pollution Prevention Plan (SWPPP).

After a careful study of site hydrology and local precipitation patterns, the contractor will install appropriate erosion and sediment control measures called Best Management Practices (BMPs). The BMPs will help reduce the turbidity of the site runoff conveyed to a retention pond for treatment. Each treatment system is designed and installed to be operated on an as need basis, pumping water from the retention basin through the CESF system on demand. Retention ponds have a site specific capacity designed to give Clear Water treatment technicians time to operate on regular schedules or respond to heavy storm events.

Upon arrival at a treatment site, Clear Water operators will complete a list of required tasks before operating the treatment system. A site inspection, meter calibrations, water quality tests, manual valve operation and paperwork initiation all must be completed before system start up can commence. The purpose of these tasks is to assure operator safety and proper system operation. After all preliminary procedures are completed the operator will start up the system by turning on the system pump(s). Operations will proceed by calibrating the chitosan delivery system, performing residual chitosan tests, manually logging water quality data, and monitoring the system for pressure and flow optimization.

When stormwater is transferred through the CESF system, chitosan is introduced to the water to coagulate suspended solids, which then will settle out via gravity or be removed within the sand filter. The sand filters are equipped with automatic backflush systems, which will backflush the filtered sediment from the individual filter pods as necessary to maintain the hydraulic capacity of the filtration media. This feature allows the treatment system to operate on a continuous flow-through basis. The treatment systems are also equipped with in line pH and turbidity sensors capable of monitoring and recording the effectiveness of the treatment. Automated valves direct treated stormwater to recirculate or discharge based on the water quality readings of the in line sensors.

After the operation period is complete the treatment technician will exercise standard and site specific shut down procedures. Familiarization with current site and weather conditions, pond water level, project manager (PM) and contractor concerns, and operation schedules are the responsibility of the technician. Good team work will ensure operational success and personal safety.

1.4 TREATMENT SYSTEM COMPONENTS

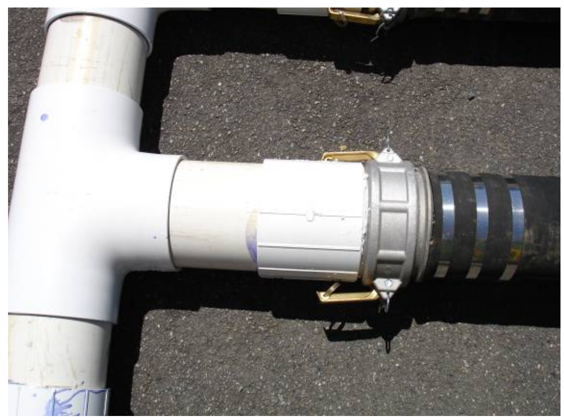
Although there are variations between individual CESF systems, many of the basic components are similar. The following is a list of the individual segments that one would expect to see associated with a CESF system.

1) Stormwater retention structure[s] — Stormwater retention structures include ponds, tanks or vaults. Ponds can either be lined or unlined; permanent or temporary. Tanks are rental units and frequently have weirs inside to facilitate settling. Vaults are permanent underground structures built for long term stormwater management.

2) Interconnecting piping — Water may be conveyed via swales, ditches or pipes to the retention structure. Interconnecting piping integrates all the components in the treatment system and conveys the water to the discharge point. Pipe types may include PVC, Bauer, flex hose and polyethylene tubes for sampling.

3) Pipe fittings – PVC pipes are typically connected with couplers and glue. Flanges are bolted together with a rubber sealing gasket. Bauer and cam lock connectors are quick disconnect fittings.



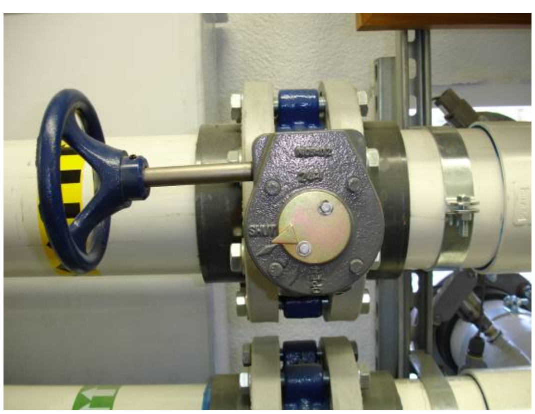
4) Primary influent and pretreat pump — The pretreatment pump is typically submersible and is attached to a float. The main pump, which pushes water through the sand filter, is shore based. Pumps are typically electric.

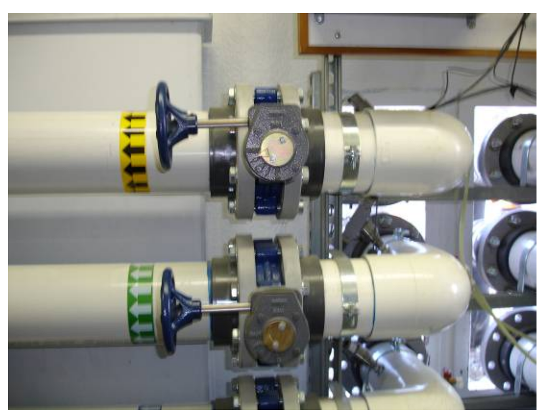

5) Chitosan injection system — The chitosan injection system consists of a storage tank, LMI delivery pump, graduated cylinders for calibration, a static mixer, and assorted tubing and control valves.

6) Sand Filtration Unit — The 54X4 sand pod unit with back flush capabilities is most commonly used. Three pod units or units with different diameters may also be encountered. Sand pods are the primary cleaning mechanism of the CESF system.

7) Effluent water quality monitoring equipment — This equipment continuously samples the effluent water for pH and turbidity. The system includes pH meters, turbidimeters, flow meters, an instrument display panel, and sample lines. Data collected here is recorded by the PLC.

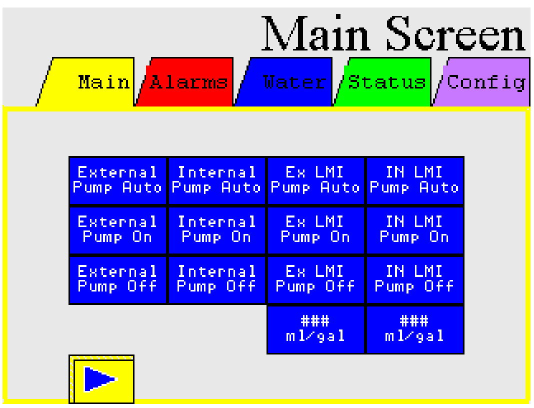
8) Manual valves — Manual valves are used by the operator to control flow rates and internal system pressures. There are manual valves located on the influent and effluent side of the sand filter, as well as on the backflush line. Additionally, a manual throttle valve may be located on the system pump.





9) Automatic valves — Automated pneumatic valves are located on the effluent line in the system container. These valves divert flow between the discharge and recirculation lines based on the water quality readings of the in-line sensors.

10) Programmable Logic Controller (PLC) — Primary control panel used to operate the treatment system. All automated controls, alarm settings, and recent system data are stored in the PLC.



11) Power Generator— These are rented units which provide electric power for CESF equipment and operations. These units are typically fueled and maintained by the contractor.

12) Laboratory Equipment — Components for bench scale testing and monitoring include handheld meters, beakers, droppers, filters, standard solutions, chemicals, monitoring forms and other miscellaneous items.

13) Air Compressor — Provides pressurized air to operate pneumatic control valves on the CESF effluent line and backflush valves on the sand filter

14) Backflush Control Box — Sets parameters for sand filter back flush cycles. Activates automatically based on differential pressure in the filter.

TREATMENT CONCEPTS AND SYSTEM DESIGN

2.1 CONSTRUCTION SITE OPERATIONS

The majority of Clear Water treatment operations take place on active construction sites. Construction sites are particularly dangerous locations and Clear Water employees should remain vigilant about health and safety issues. Constantly changing conditions, unstable surfaces, heavy equipment operations, as well as other issues all contribute to site hazards.

Health and safety precautions are extensive and beyond the scope of this manual. Clear Water technicians should refer to the site specific Health And Safety Plan (HASP) for safety issues pertaining to each job site. The weekly checklist included in the HASP needs to be read and signed by every Clear Water employee that visits a site for that particular week.

2.2 STORMWATER REGULATIONS

Construction stormwater runoff has been identified as a major source of pollution in our nation's natural waters. The physical, biological and chemical integrity of a natural water body receiving discharge from a construction site can be greatly impacted.

The two major laws that most stormwater regulations emanate from are the Federal Clean Water Act and Endangered Species Act. The Environmental Protection Agency is ultimately responsible for enforcement of these laws, but may delegate enforcement to a state agency. The Department of Ecology (DOE) is the regulatory authority for these laws in the state of Washington. (Note: many Clear Water treatment procedures are based on DOE regulations. Always consult local regulations before operating CESF systems.)

Whenever Clear Water intends to treat runoff from a particular construction site a Stormwater Treatment Plan (STP) must be produced as mandated by DOE. This STP explains exactly how the CESF system will be used on a specific site as part of an integrated Stormwater Pollution Prevention Plan (SWPPP). An STP will be included inside every active CESF system container. All operators should read the STP for any site they are working on to become familiar with site specific and general operational information.

There are many other stormwater regulations that are beyond the scope of this text. Increased knowledge of stormwater regulations will improve an operator's effectiveness. Additional information is available through other Clear Water resources, as well as the DOE website.

2.3 WATER CHEMISTRY

Effective implementation of a treatment system requires a thorough understanding of site stormwater characteristics and the potential impact on chitosan flocculation. Potential contaminants such as VOCs, PCBs, heavy metals, etc., must be identified and remediated prior discharge. Other compounds such as naturally occurring lignins and tannins can impact the CESF treatment process but do not pose a concern for discharge.

CESF systems are designed to treat turbid stormwater impacted with suspended sediments. Many environmental contaminants can be adsorbed to soil particles and become suspended in stormwater runoff. Many of these contaminants can be removed from solution by removing the sediment. Although this can be a beneficial side reaction in CESF treatment, Clear Water makes no treatment claims for stormwater runoff other than turbidity.

Prior to full-scale deployment, it is essential to conduct a series of bench scale treatability tests to ensure the stormwater sediment is conducive to treatment with chitosan. These tests should be focused on determining stormwater turbidity and pH, treatability, proper chitosan dose rate, and potential settling times if required.

Aside from harmful contaminates, the water chemistry variables of primary concern are pH, turbidity and conductivity. pH must be in the range of 6.5 — 8.5. Values outside this range will require pH adjustment prior to flocculent addition. Typical pH adjustment involves either adding Sodium Bicarbonate to adjust the pH upward or adding dry ice (CO_2) to adjust down. The use level designations require pretreatment for stormwater greater than 600 NTU.

Although CESF systems are capable of continuous operation when turbidity approach 600 NTUs, experience has shown that optimal system function is typically limited to influent turbidities less than 200 NTU. Generally, typical pre-treatment activity will bring NTU levels well within range of sand filter use. High turbidity (in excess of 600 NTU for an extended period of time) may require reevaluation of existing site Best Management Practices (BMPs).

2.4 SCREENING AND TREATABILITY TESTS

It is essential to confirm early on that site stormwater is conducive to treatment with chitosan. A simple bench scale treatability test enables Clear Water technicians to assess the treatability of site stormwater quickly in the field.

Bench scale treatability testing allows PMs and system operators to determine a likely chitosan dose range. On large sites, it is strongly recommended that Clear Water technicians perform treatability tests using samples from several different areas of the site.

Several factors can influence treatability, including pH (typically from concrete work onsite or natural limestone), detergents, the presence of soil tackifiers such as polyacrylamides (PAMs) and guar in the runoff.

Bench scale treatability tests should be done multiple times prior to system deployment to identify and address treatability issues early on. Treatability tests are also to be preformed daily before system start-up and whenever conditions on the site warrant reevaluation.

The procedure for this test is described in the section 3.6 of this manual

2.5 RETENTION STRUCTURES AND SEDIMENT MANAGEMENT

Stormwater retention ponds and traditional erosion control devices are the first line of defense in sediment management. CESF systems are more effective when properly integrated into a SWPPP that uses traditional erosion and sediment control techniques. Actual sizing and placement of retention structures and BMPs is beyond the scope of this document. Regardless of the type and size of structure, the following components are necessary for implementation:

1) Traditional BMPs — Traditional BMPs are essential to proper stormwater management. These surface stabilization measures help prevent significant erosion and sediment movement. CESF is intended to aid, not to substitute, standard stormwater management techniques.

2) Primary retention structure — The water reservoir in which all untreated stormwater is directed and stored. This is typically an excavated pond prepared by the contractor to store site runoff. The storage capacity of these structures varies depending on the size of the disturbed area and site limitations.

3) Pretreat retention structure — Secondary retention structure in which pretreated, unfiltered stormwater is allowed to settle prior to sand filtration. These structures can be ponds or above ground tanks. Ideally these structures will contain weirs to reduce and dissipate energy in the flowing water and aid in sediment settling.

4) Backflush (from the sand filtration system) — Backflush water will contain floc particles accumulated on the surface of the sand filter beds. These floc particles will settle rapidly in the retention structure due to their large size and density. The rate of settlement will depend on sediment load, water chemistry and flow rate. Backflush water should never be directly released into the receiving water body.

Every effort should be made to avoid routing backflush water to the primary retention structure. Ideally, the backflush outflow should be directed to a dedicated backflush tank which overflows into the pre-treat cells. At minimum, the backflush outflow should be directed to the opposite end of the retention structure from the intake pump.

- If there is any possibility that the coagulated/flocculated sediment (sludge) contains hazardous materials, then the retention structure should be lined to facilitate proper handling and disposal of contaminated sediments. Lining the retention structure will also prevent unwanted infiltration of untreated water.

- Disposal — Sludge may be dewatered and disposed of onsite. Contaminated sediment should be handled in accordance with applicable regulations and permit stipulations.

2.6 INTERCONNECTING TREATMENT SYSTEM PIPING

The filtration system requires interconnecting piping capable of transferring desired flow rates without significant friction head losses. Typically, schedule 40 polyvinylchloride (PVC) pipe and flexible hose is used to interconnect the system components. Sizing should be in accordance with system requirements, and will generally be as follows:

PIPING SIZES AND FLOW RATES

FLOW RATE	*PIPE SIZE*
Up to 350 gpm	**4”**
350-750 gpm	**6”**
+750 gpm	**8”**

The headers on the sand filter and the internal piping of the treatment system container are 6 inches in diameter. The ideal diameter of the external system piping is 6 inches which will maintain consistent pressures and flow rates. Reducing the diameter of a conveyance line (pipe) will increase the pressure the water exerts within that line. Conversely, increasing the diameter down a conveyance line will relieve the pressure in that line.

The treatment system container has hand operated flow control valves located on the influent and effluent lines for the sand filter. These valves control pressure and flow rates in and through the sand filter. In addition, the sand filter has a flow control valve located on the back flush line. Flow control throttle valves may also be located on the system pumps.

2.7 PLUMBING

As the treatment system container and sand filter is equipped with 6" pipe, it is recommended that 6" pipe be used to connect the system components. There are many factors that influence the type and size of pipe used for a CESF system which are beyond the scope of this manual. PVC or Bauer pipe are most commonly used for field mobilization but different types of flexible hose may also prove necessary in certain configurations.

Most CESF systems are equipped with pretreatment and backflush capabilities. The backflush line from the sand filter is a 4" header and will require 4" pipe. The pretreat line will require a pump separate from the main system pump and will typically be assembled using 6" pipe and fittings.

Before plumbing the system, make sure all required system components are in place and as level as possible. This includes the system operation container, water pumps, electrical generator, sand filter and any tanks.

CAUTION: BE SURE TO LEAVE ACCESS TO THE TREATMENT CONTAINER AND GENERATOR FOR ANY VEHICLES NEEDED TO RESUPPLY CHITOSAN AND DIESEL!

If the pump being used is submersible it should be connected to a flotation device prior to placement in a pond. Many types of flotation devices are used. The decision on which type to use needs to be made based on the size of the pump. If the pump being used is not a submersible pump, the intake line should be connected to a suction float with a debris screen. Flotation devices and screens prevent the introduction of rocks, sticks, mud and other debris to the pump. This can prevent costly maintenance, repairs, replacements and operational time loss.

The order in which the system is plumbed will depend on the physical configuration of the site. For the purpose of this manual the mobilization procedure will be described in the chronological order of the system water flow. The following list is generalized and site specific adjustments may apply.

- **Connect the pretreat pump.** Any flotation devices should be connected to influent before placement in the water. Run the line from the water to the pump, then from the pump to the bottom header at the front of the treatment container. Tape on the headers in the system container indicates direction of flow.

- **Connect pretreat line between system container and pretreat retention structure.** A distance of at least 50 feet is desired to maximize the mixing of the chitosan and the stormwater. Water should be released into the retention structure above the surface.

- **Connect line from pretreat retention structure to sand filter pump.** The water intake line from the pretreat retention structure should be as far as possible from the point where the pretreated water is introduced to the structure. This placement will take advantage of the maximum possible settling time of the sediment.

- **Connect line from system pump to treatment container.** This line will go from the pump discharge to the middle header at the front of the treatment container. Tape on the header in the container indicates flow direction.

- **Connect line from middle header effluent to the sand filter.** A distance of at least 50 feet is desired to maximize the mixing of the chitosan and the stormwater. This line will run to the top 6” header of the sand filter.

- **Connect line from bottom header of sand filter to treatment container.** This line will go to the top header at the front of the treatment container. Tape on the header in the container indicates direction of flow. This line will branch in to two effluent lines, each with an automated valve. The lower of these lines is the discharge effluent line. The top line is the recirculation line.

- **Connect discharge line.** This line will run from the container to the discharge location.

- **Connect recirculation line.** This line will run from the top effluent pipe and typically run into the primary retention structure consultant the PM for site specific modifications.

- **Connect backflush line.** This line will run from the 4” header on the top of the sand filter to the primary retention structure or separate backflush cell. This line should introduce water to the retention structure as far as possible from the pretreatment influent line to minimize uptake of suspended solids.

2.8 CHITOSAN DELIVERY SYSTEM

The chitosan deliver system consists of a chitosan storage container, secondary spill containment structure, metering pump, graduated cylinder(s) for calibration, static mixer, interconnecting tubing and valves. A secondary spill contaminant structure is required by regulatory agencies to provide containment in case of accidental spills. Consideration should be given to regular chitosan supplying procedures when installing the treatment system on site.

The metering pumps for the sand filtration systems are LMI Model C77 variable speed chemical metering pumps with high viscosity head assemblies. This pump is a variable-output, positive displacement metering pump with a flow rate range of 0-10 gallons per hour at 80 psi. These pumps are explicitly specified in the use level designations. Individual pumps are typically installed for the pretreatment and filter influent dosing.

PISTON SPEED AND DISPLACEMENT RATE SHOULD ONLY BE ADJUSTED WHILE PUMP IS IN OPERATION!

The capacity of a chitosan storage container can range from 150 to 275 gallons. The operational time frame of a storage container can last from several days to several months, depending on dose rate and the volume of water treated. Ball valves are installed on the chitosan delivery lines for meter calibration purposes. The static mixers installed on the pretreat and sand filter influent lines increases the mixing rate within the pipes. Incorporation of static mixers into Clear Water's CESF systems has reduced the required chitosan contact time, the overall system footprint, and decreased chitosan utilization by 25 to 50%.

The dose rate will depend on influent turbidities, water chemistry, and local regulatory agencies. The use level designation specifies a maximum allowable dose rate of 1ppm. Under certain conditions DOE will increase maximum allowable dose rate to accommodate specific site conditions. Follow the bench scale treatability protocol to determine the likely dosage range.

2.9 WATER QUALITY MONITORING

Local, Regional, State (use level designation), and Federal regulations will determine the scope of water quality testing that must be performed on the site. Construction permit and SWPPP approvals from applicable environmental jurisdictions will typically state what testing must be performed, how often, and who should receive the results. These regulations will often effect system discharge location and volume.

The treatment system is designed to monitor effluent turbidity and pH, and to automatically divert flow from discharge to recirculation should these values exceed permit limits. Influent water quality parameters are also monitored by the system PLC but do not trigger any flow diversions.

Clear Water treatment technicians must calibrate system sensors on a daily basis to ensure reliability of the automated process. Additionally, technicians must perform multiple manual water quality tests as dictated by the use level designation. Hand held meters must be checked and compared to the in-line meters on a daily basis. This procedure is referred to as a Confidence Check.

Other water quality parameters governed by local regulatory agencies must be monitored and addressed by the system operator. Sample ports are provided in the system to take water samples for bench scale monitoring. The filter influent and effluent headers each have one sample port feeding into the system's flow-through water quality sensors. The influent port samples pure runoff or pre-treat water before it gets dosed for the sand filter. The effluent port samples water after if has been filtered but before it is discharged. Water sampled for residual chitosan tests should be drawn from the effluent port to prove the absence of residual chitosan.

TREATMENT SYSTEM OPERATIONS

3.1 SYSTEM OPERATOR

The stormwater filtration system shall be operated, monitored and maintained by experienced water filtration personnel as required by the use level designation. The system operator should have previous training or should be trained during the first several days of operation under the guidance of an individual experienced in chitosan-enhanced water treatment systems.

3.1.1 Required Operator Qualifications

1) Minimum 1 year experience with, and sound working knowledge of, pressurized sand filtration systems.

2) Experience deploying and troubleshooting pressurized water pumping and piping systems.

3) Fundamental knowledge of stormwater discharge regulations for applicable region/locale.

4) Fundamental knowledge of water quality testing procedures for parameters applicable to the region/locale.

3.1.2 Required Operator Training

Classroom training (8 hours)

1) Stormwater regulatory framework and requirements

2) Stormwater treatment chemistry (chitosan, pH, coagulation, filtration,

etc.)

3) Stormwater treatability (how to do jar testing)

4) Treatment system components and their operation

5) Troubleshooting

Field Training (40 hours)

1) Operating a treatment system

2) Entering data in the system operation log

3) Testing turbidity and pH

4) Optimizing chitosan dose rate

5) Water quality sampling and testing (turbidity and pH)

3.2 SYSTEM OPERATION SEQUENCE

The typical operational sequence for starting and stopping systems is given below. System, site, and regulatory variations must always be considered. The following sequence is intended to be a general outline for CESF operations, not a comprehensive protocol.

3.2.1 System Start Up

1) Perform site and system inspection procedures (section 3.3). Examine system for obvious damage or malfunction. Unlock container and power up the system. Orient all valves for operation in recirculation mode.

2) Turn on the sensors. Read and record system volume totalizers in the Daily System Operation and Maintenance log. Record any other relevant system information.

3) Calibrate hand held pH, turbidity and conductivity meters.

4) Take a grab sample from primary retention structure and perform bench scale treatability test to determine likely chitosan dosage.

5) Perform water quality background check. This includes taking grab samples from the receiving water body and recording pH, turbidity and conductivity in the appropriate field log.

6) Calibrate inline pH and turbidity meters.

7) Switch PLC to recirculation mode. Recheck manual valve orientation.

8) Start the filtration system pumps using system PLC screen and watch for proper system functioning.

9) Start LMI pumps

10) Calibrate LMI pumps to deliver proper chitosan dosage

11) Once LMI pumps are calibrated and all discharge conditions are met, switch system to automatic mode by touching the “valves auto” button on the main screen of the system PLC.

12) Collect samples of sand filter effluent and perform the residual chitosan test.

13) Treatment technicians will remain on site while the system is in operation to monitor overall system performance. System pressure and inline water quality results are to be recorded every fifteen minutes in the appropriate field log.

14) Residual chitosan tests are to be performed twice during the first two hours of system operation. LMI calibrations are to be performed every four hours after start up calibration, or when a significant change occurs in the dose rate or influent turbidity

3.2.2 System Shut Down

1) Begin system shut down by switching system back into recirculation mode.

2) Turn off main system pumps and LMI pumps.

3) Open sand filter bleeder and/or drain valves and let water drain from the recirculation line.

4) Record flow meter totalizer readings in the appropriate field log. Note any operational anomalies and certify operations.

5) Follow shut down procedures for inline pH and turbidity meters (Section 3.15).

6) Drain air compressor using manufacturer installed drain plug.

7) Clean and organize the treatment system container.

8) Close all applicable system valves (inline sample; chitosan storage tank; water storage tank; pneumatic valves).

9) Turn off all extraneous power in the system and lock the container.

3.2.3 Freeze Protection

During cold weather conditions, certain precautions need to be taken to protect against freeze events. A freeze event could result in system component damage and/or operations loss.

1) All conveyance lines should be drained. Frozen pipes could result in flow blockage and/or pipe fracture. Ball valves are likely installed on conveyance

lines to drain water for freeze protection. Disconnect low end cam-locks or Bauer fittings for drainage if necessary.

2) Sand filters should be drained. Bleeder valves on the top of the sand pods should be open to aid in filter drainage. Drain valves may be installed on the bottom header for more direct filter evacuation.
3) System Container should be kept heated at all times. Generator, system, and heater should all be left in “auto”. Extreme cold conditions can cause instrument damage, plumbing damage and will affect the hydraulic performance of the chitosan. The properties of some of the chemicals may be compromised if they freeze.

3.3 SITE AND SYSTEM INSPECTION

A preliminary assessment should be made of the overall integrity of a job site upon arrival. Conditions may have changed at the site in such a way that affects treatment operations. In addition, standard operating procedures must be performed prior to system start up.

Overall site integrity: Construction sites are in a constant state of change. Be aware of major physical changes such as road additions or removal, vegetation removal, sanitary facility location, site access points, excavations and heavy equipment operation.

Pond Level: Check pond level upon arrival. Report excessive pond levels immediately. Observe pond level prior to system startup and monitor level frequently during operation. Note both increases and decreases in pond level to assure efficient staffing and operation.

Pipe Integrity: Check to see if all the conveyance lines are in working order. Surface pipes on construction sites are vulnerable to vehicle impact, vandalism, and environmental damage. Small stress cracks can become significant safety or operational problems when operating under pressure

Freeze Protection: Close all drain valves that may be affixed to water conveyance lines or the sand filter. These valves are left open to drain excess water from the lines in cold weather. Water expands as it freezes and PVC pipe becomes more brittle in cold weather. This combination can render a system inoperable.

Manually Operated Valves: Switch any manual valves to the proper position for site specific operations. Some valves associated with system operation are automatically controlled by the PLC. However, some systems may incorporate manual valves for pretreatment cells, multiple retention ponds, or multiple discharge locations. If you are unsure about proper valve positions, contact the project manager.

Hose/Pipe Connections: Shut down protocols on some sites require operators to disconnect specific conveyance lines to drain the system. Assure all necessary conveyance piping and hoses are attached to appropriate system equipment.

Generator Fluid Levels: Check the fluid levels (fuel, oil, water) on the system power generator to see if the equipment needs to be serviced. If any fluids are low or warning signals lit, contact the project manager.

Equipment Theft: Power cables, generators and hand tools are a frequent target of theft. Check to see if any operational equipment appears to be missing or tampered with.

Unlock Container: All Clear Water treatment containers are kept locked when company personnel are not present. Keys for all treatment containers will be provided by the PM.

Power Up System: A treatment system will likely be in AUTO or OFF upon arrival. CESF system key switch and generator should be set to ON during system operation.

Chitosan Injection System Valves: The chitosan storage tank valve should be shut at the end of every shift to protect against chitosan leaks. Open any valves necessary for proper chitosan injection.

Sand Filter Bleeder and Drain Valves: Small bleeder valves at the top of the sand filter pods are typically left open at the end of system operations to aid in the drainage of the sand filter. Make sure these valves and drain valves are closed before introducing water to the filter.

Sample Port Valves: Water quality sampling lines should be closed at the end of system operations. Keep these valves closed until the inline water quality meters have been calibrated. Open the valves before system operations.

Air Compressor: Turn on air compressor if it is turned off. Make sure the compressor breaker switch is on. Check to make sure the previous operator drained the compressor of water and the drain valve is closed.

Chitosan Volume: Asses the quantity of chitosan in the storage tanks. Site PMs need to be kept aware of chitosan levels so they can schedule a timely resupply.

3.4 FIELD DOCUMENTATION

A series of triplicate forms are provided in all the system containers for technicians to log the results of operational activities. Completion of these forms is necessary for compliance with Clear Water and regulatory procedures. The complete set of forms is to be used during every operational period.

All the forms have a field to record the project title, project number, project location and date in the header block. System operators should print and sign their name at the bottom of the sheet. If multiple operators are working in a single system container, the forms should be signed by the most senior operator. All fields on each form are to be completed. Fields are never to be left blank. Fields which do not apply to a particular site or system should be completed with the letters NA (not applicable).

CESF – Daily System Operations and Maintenance: This is the primary form used by Clear Water operators. The pre and post treatment flow totalizer numbers as well as the total volume treated and the total volume discharged are recorded here. This form is intended to summarize system activities and productivity. Regulatory agencies require an evaluation of system performance and water quality monitoring for all discharge periods. Other relevant operational information should be recorded here for reference by Clear Water staff.

Bench Scale Treatability Form: This form is used to record water quality data and the observed results associated with the bench scale treatability test. The procedure for this test is described within this manual. Visual observations should be recorded in conjunction with each dose adjustment. Additionally, a general assessment of the entire test should be recorded upon completion of the test.

Receiving Water Quality Monitoring Form: The receiving water quality form is used to record the results of upstream and downstream conditions in the receiving water body. The observations recorded on this form are used to assess any impacts CESF discharges may impose on the receiving water. This form has limited usability on some sites because of the location of the discharge or type of receiving body.

Chemical Metering Pump Calibration Form: This form is used to record the LMI chemical delivery rate and calculate the treatment system dose rate. The chitosan calibration procedure is described within this manual. Chitosan injection pumps are to be calibrated upon system start up and every four hours thereafter.

Residual Chitosan Test Form: This form is used to record the results and sample data associated with residual chitosan tests. The procedure for this test is described within this manual. This residual chitosan is to be performed twice during the first two hours of CESF operation. Operating conditions that necessitate elevated chitosan dose rates may increase the residual chitosan testing requirements.

Manual Data Collection Form: This form is used to record inline water quality data (pH, Turbidity) as well as system pressure. Influent and effluent data should be recorded for each of these three categories. This data should be recorded every 15 minutes and logged in military time. This data should be read from the “water” page of the PLC. In addition, daily meter confidence checks should be recorded on this form.

Instrument Calibration Report Form: Clear Water’s CESF systems have multiple water quality meters which need to be calibrated daily. There are separate forms associated with inline pH meters, inline turbidity meters, and all the hand held meters. There are fields to record the strength of the calibration standard used, the initial meter reading, and the calibrated meter reading.

3.5 SENSOR CALIBRATION

The systems internal water quality sensors, as well as the hand held sensors, should be calibrated daily before operations begin. Log the calibration information for each instrument in the accompanying calibration form. Daily calibration of the sensors is directed in the use level designation and will help ensure accuracy of water quality monitoring.

Confidence Checks must be performed to confirm sensor accuracy. Hand held readings should be checked against inline readings during the residual chitosan tests. An additional Confidence Check is to be performed and recorded six hours after system start up. Confidence Checks are to be recorded in the Manual Data Collection Form.

The manufacturer provided calibration procedures for each meter are included as an attachment in this manual. Additionally, the entire owner’s manual for the hand held meters are included inside each treatment system. Calibration standards for the inline and hand held turbidimeters are included in the corresponding meter kits. Calibration standards for the inline and hand held pH meters are supplied within the treatment system containers. The calibration standard for the conductivity meter is supplied within the treatment system container.

3.5.1 Hand Held Meter Calibration

Hand held meters are to be calibrated at the beginning of each operational shift. A separate set of forms are included specifically for calibrating the hand held meters.

These meters must be calibrated prior to the preliminary water quality tests. Follow the included manufacturer's instructions for proper calibration procedure.

3.5.1.1 Hand Held pH Meter

It is important to properly care for the pH meter probe. Irreparable damage to the probe commonly occurs due to simple neglect. pH probe storage solution and cleaning solution is included in the treatment system containers. Use the cleaning solution periodically or whenever its use appears necessary. Store the probe in probe storage solution whenever the meter is not in use. The tip of the probe should never be allowed to dry out. The probe should be rinsed with water between insertions of different standards or samples to avoid contamination.

3.5.1.2 Hand Held Turbidimeter

The included cuvettes for calibration standards and sample measurements need to be handled carefully. The readability of the glass cuvettes will be compromised if they get scratched. Avoid touching the cuvettes with your bare fingers and carefully remove smudges with laboratory wipes. The cuvettes can become stained if dirty samples are allowed to sit inside for an extended period. Always promptly empty samples and rinse the cuvettes with distilled water after use. Clean stained cuvettes with a gentle solvent.

Make sure the outside of the cuvettes are dry before inserting them into the meters. Introducing moisture into the meters will compromise sample reading and damage the meter.

Record the Initial Reading before calibrating the meter. Record the Final Reading after calibrating the meter.

3.5.2 Inline Meter Calibration

Inline meters are to be calibrated at the beginning of each operational shift before stormwater treatment begins. Record calibration data in the appropriate forms. Follow the included manufacturer's instructions for proper calibration procedure.

3.5.2.1 Inline pH Meter

Follow the probe care and usage instructions previously stated for the hand held meter.

Calibrate the pH meter using the EASYCAL method identified by the manufacturer. Choose a calibration slope appropriate to the stormwater that will be treated for that shift (7 to 4 if water is under 7; 7 to 10 if water is over 7). Finish the calibration procedure by measuring the calibrated reading of the pH 7 buffer. This will ensure the meter is reading within the range of the stormwater being treated. Record the Initial Reading when the meter is in calibration mode and record the Final Reading when the meter is back in normal operation mode.

Carefully remove and replace probe from probe seat. Probe-amplifier lock points can be damaged if not removed gently. Cross threading is a common problem with the pH seats. Be aware of the O-ring gasket falling out when removing probe from pH seat.

3.5.2.2 Inline Turbidimeter

Follow the cuvette care and usage instructions previously stated for the hand held meter.

Be aware of condensation on the flow through cuvette when calibrating between 24 hour operational periods. Cold water in the cuvette and the warm air inside the treatment container will often promote condensation which would need to be wiped off before returning the cuvette to the measurement chamber.

Record the Initial Reading and Final Reading when in calibration mode.

3.6 PRELIMINARY WATER QUALITY TESTS

After the water quality sensors have been calibrated the system operator can perform the bench scale treatability and receiving water quality tests. These tests are used to assess the conditions of the stormwater to be treated and the receiving waters. The technician may have to adjust treatment system operations based on the water chemistry results of these tests

3.6.1 Bench Scale Treatability Test

The bench scale treatability test lets the operator know of possible treatment problems prior to introducing water to the CESF system. Several factors can influence treatability, including pH (typically from concrete work onsite, or natural limestone), detergents, the presence of soil tackifiers such as polyacrylamides (PAMs) and guar in the runoff.

Conditions in the bench scale test are different than conditions inside the treatment system. For this reason different treatment outcomes may occur between bench scale tests and system operations.

The samples procured for this test should be representative samples from recent runoff, and should not contain sediment that would settle naturally (sand and rocks). On large sites it may be prudent to collect multiple samples from different points on the site and perform separate tests.

3.6.1.1 Required Equipment

In order to perform this testing sequence, the following items are required:

- Properly calibrated pH meter
- Properly calibrated turbidimeter
- Properly calibrated conductivity meter
- One 1-liter sample glass beaker
- One 1-liter sample plastic beaker
- Chitosan acetate
- Pipette
- Stir rod

3.6.1.2 Perform the Screening Test

1) Retrieve a one liter grab sample of stormwater from the site retention pond with a plastic beaker.

2) Transfer the sample into a one liter glass beaker

3) Measure and record initial pH, conductivity and turbidity of sample in the appropriate field log.

4) If the sample does not have a pH reading conducive to treatment (6.5 – 8.0), carefully adjust the pH of the sample by adding small amounts of sodium bicarbonate or acetic acid until the sample reads a pH close to 7. Record the adjusted pH and note treatment method.

5) Add one drop of a known quantity chitosan to the sample.

6) Stir sample vigorously for one minute to assure dissolution.

7) Allow sufficient settling time and observe solution for the formation of small floc particles called pinfloc.

8) Grab a sample from the surface of the sample jar and record the turbidity.

9) Repeat steps 3 through 4, recording observations and dosage related to the appearance of floc and settling.

3.6.1.3 Interpreting the Screening Test

Visible sediment settling indicates that chitosan has coagulated the particles. The beaker may contain clear water on top, or be slightly cloudy, and there should be variation in coagulation amount between dose rates. The object of this test is not to produce completely clean, clear water in the beaker. Rather, it is to determine the most suitable dose rate for CESF treatment.

For planning purposes, the smallest effective dosage should be used as the initial dose rate.

If there is no change in sample appearance between doses it is assumed that there are treatability problems. This is rare, and may occur for different reasons which need to be investigated.

3.6.2 RECEIVING WATER QUALITY TEST

Receiving water quality tests are designed to measure if discharge from CESF operations is negatively impacting the receiving water body. Site specific conditions may force the system operator to amend or even abandon this test all together. Certain discharge points, such as municipal storm sewers or overland infiltration, make it physically impossible to obtain a sample for this test.

This test is designed for a linear flow water body such as a river or stream. The procedure for this test will be described for such a water body. PMs and treatment technicians may need to improvise sample collection procedures if site conditions are inconsistent with this assumption.

1) Before system start-up, take two 1-liter beakers to the discharge point to obtain grab samples. Take one sample several yards upstream and one sample several yards downstream of the discharge. Always wear nitrile laboratory gloves when taking grab samples. Operators must not place themselves in precarious situations to obtain a sample. NO JOB IS TOO IMPORTANT TO NEGLECT SAFETY CONCERNS!

2) Return samples to the system container to measure the water quality. Measure pH, turbidity and conductivity of each sample with hand held meters. Record the sample location, time and water quality data for the two samples in the top two columns of the Receiving Water Quality Form.

3) After several hours of operation, return to the system discharge point and take one sample from each of the previously identified locations. Return these samples to the system container to measure water quality. Record the water quality data along with the location(s) and time(s) on the bottom two columns of the form.

4) Compare the two data sets. Ideally there will be a negligible difference between the data sets. If there is a significant difference between the two data sets, it should be recognized as evidence that system operations are impacting the receiving water body. Operators should notify their project managers in such a case.

3.7 PUMP ACTIVATION

After meter calibration and preliminary water quality tests are completed, the operator is ready to introduce water to the CESF system. Operators should always verify all manual valve positions to ensure the pressurized water has a clear and proper path of entry and exit through the treatment system. Closed pathways will dead head the pump which can lead to equipment damage and/or safety concerns.

Attention should be paid to the water levels of the primary and (if applicable) secondary retention ponds. Pretreatment should be momentarily delayed if the secondary cell is full. Filter treatment should be delayed if the secondary cell is empty. Overflowing retention structures can result in stormwater runoff violations. Pumping of a dry retention structure can cause pump damage. Pretreatment and primary pumps often do not deliver water at the same rate. Treatment technicians should continually check pond levels and pump flow rates and adjust pump operation accordingly.

3.7.1 Pump Activation Procedure

1) Open the automated recirculation valve by pressing the “Recirc Valve On” button on the Main Screen window of the PLC. Visually confirm that the valve has opened.
2) Toggle over to the secondary Main Screen window by pressing the yellow and blue arrow on the bottom of the screen. All the buttons on this screen supply power to individual pumps.
3) Switch on pretreat and/or main pumps, based on retention structure(s) water level by pressing the “External Pump On”/”Internal Pump On” button(s) accordingly.
4) Switch on the corresponding pretreat and/or main LMI pumps by pressing the “Ex LMI Pump On”/”In LMI Pump On” button(s).
5) Check associated components as water begins to run through the treatment system including, air compressor, backflush control box, flow meters, and flow through sample lines.

6) Observe pressure gauges to assure the CESF system reaches an acceptable operating pressure.

3.8 SYSTEM OPTIMIZATION

CESF systems usually take several minutes to reach full operating pressure after pump activation. Clear Water technicians should take this time to confirm proper system operation. Systems which have been operated recently and frequently will generally reach optimum operating conditions soon after pump activation. Systems which are starting up for the first time or have not been operated for a long time will require some adjustments to reach optimum operating conditions.

3.8.1 System Optimization Procedure

1) After pump activation, confirm that the air compressor is receiving power and delivering the proper pressures. Compression chamber pressure should be 100+ psi and line pressure should be 60+ psi
2) Visually confirm water discharge. Walk over to the discharge (recirculation) point to observe this. No water or decreased water flow indicates possible system breach.
3) Confirm that the flow sensors are working. There are different types of flow sensors and the reason for failure may differ. If the flow meter is not registering flow but system flow is evident, the sensor may need to be inspected. This process involves system shut down, water main evacuation and removing the meter for inspection.
4) Confirm backflush control box is powered. The backflush control box automates all backflush operations. Loss of backflush will result in filter sand bed impaction. Check main power, breaker switch and power cord if box is not powered.
5) Confirm sample line flow. Polyethylene tubes which convey the water quality samples should dispel water through one of the penetrations in the container. No outflow from these tubes indicates the water quality readings are not representative of the treated stormwater. Check for proper valve orientation and/or clogged lines.
6) Optimize flow rates. The maximum discharge flow rate for a specific site will be specified in the Stormwater Treatment Plan. Adjust manual valves to achieve desired flow rate.
7) Optimize system pressure. Optimal system pressure depends on the specific system and will vary from site to site. Variables such as pump capacity, plumbing configuration, filter size, discharge rate and water treatability will all affect system pressure. Typical system pressure should range between 30 and 50 psi. System pressures can be as low as 20 and as high as 50 with no operational impediments. Opening the influent valve will increase system

pressure and increase system flow. Opening the effluent valve will decrease system pressure and increase system flow.

3.9 pH TREATMENT

Although pH treatment is not included in all CESF treatment regimens, it is not unusual. Many of the sites that require pH treatment require it on a consistent basis while other times it may be sporadic or short term.

pH treatment is required for regulatory and operational purposes. These two requirements are not necessarily unrelated.

Regulatory requirements dictate runoff from construction sites that discharge to non-marine surface waters must have a pH between 6.5 and 8.5. Most natural waters are well within that range. Many aquatic species are very sensitive to pH alterations and even a small alteration can have a significant effect on a natural system.

Stormwater pH must stay in the same range of 6.5 to 8.5 for CESF treatment. The chemical reaction which facilitates chitosan flocculation is optimized within this range. Outside of this range, the effectiveness of chitosan as a flocculent is severely compromised.

pH treatment for CESF systems is generally done with one of two chemicals. Sodium Bicarbonate raises low pH and CO_2 lowers high pH. Beware of over correction. Adding too much chemistry for pH correction will render water untreatable.

SODIUM BICARBONATE: Adding Sodium Bicarbonate to acidic water (pH below 7) will raise the pH to a treatable level. Sodium bicarbonate is typically supplied to CESF system operators in 50 lb bags. It is most effective to add the chemical to a point in the system where it can be physically disturbed and dissolved. The point where pressurized water is discharged into a settling pond would be an ideal location.

CO_2: Adding CO_2 to caustic water (pH above 7) will lower the pH to a treatable level. CO_2 is supplied to CESF system operators in the form of dry ice or in a compressed gas or cryogenic tank. Dry ice is most effective when introduced to a retention structure near the region of pump uptake, right before chitosan is injected. Cryogenic tanks are normally supplied when pH treatment will be a regular process and there will be a dedicated “sparge” tank for gas injection.

3.10 LMI CALIBRATION

Clear Water technicians will operate and calibrate the chemical metering system consistent with the use level designation requirements. Technicians will calibrate the chemical metering system at system startup and every four hours thereafter during system operation to ensure that the dose rate is at or below 1.0 ppm at all times. Additionally, the metering pump shall be recalibrated when a significant change occurs in either the flow or influent turbidity. Calibration results and flow rates will be recorded on the CESF system monitoring forms and the calibration records will be kept onsite.

OPERATIONAL NOTE: LMI pump dials should **ONLY** be adjusted when pumps are **OPERATIONAL.** Adjusting pump dials while pump is not running will likely result in pump damage and/or failure.

When adjusting the metering pump to obtain proper dose rate, there are two primary adjustments: stroke frequency and stroke length. Experience has shown that the stroke frequency should be set as high as possible for a consistent rate of delivery, and then the stroke length adjusted to deliver the desired dose rate.

Some CESF chemical injection systems have a dedicated delivery line for each pump, while other systems have multiple pumps connected to the same line. Operators should consider the design of the injection system being calibrated when executing this procedure. Systems that have multiple pumps plumbed to the same line will require the operator to isolate the unmeasured pump from the system during calibration.

Upon initiation of this procedure, the valve on the chitosan storage tank should be open and both system pumps and chitosan delivery pumps should be operating.

Calibration Procedure:

1) Fill the calibration cylinder by opening the valve on the bottom of the cylinder. Fill the cylinder as close to full as the static head pressure on the storage tank will allow without over filling.
2) Close the valve on the chitosan storage tank.
3) Allow the LMI pump to drain the cylinder to a desired volume and then begin timing the pump for one minute.
4) Close the cylinder valve at exactly one minute.
5) Immediately open the valve on the chitosan storage tank
6) Read and record the volume of chitosan consumed
7) Calculate the dose rate using the calculation table below. Pair the chitosan consumption rate with the corresponding stormwater flow rate.
8) Convert delivery rate from ml/min to mg/min (multiply result by 10 for 1% chitosan) and flow rate from gal/min to L/min (multiply by 3.78). Divide chitosan delivery rate by flow rate to get does rate (ppm). Refer to formulas presented below.

9) Adjust delivery rate toward desired dose rate* if necessary and repeat procedure until proper dosage is achieved.
10) Record the final results in the Chemical Metering Pump Calibration Form.
11) Repeat procedure for next LMI pump.

1. Liqui-Floc delivery rate (ml/min) x 0.01 (chitosan concentration) x 1g/ml (weight of Liquid-Floc) = absolute weight of chitosan in g/min
2. Chitosan delivery (g/min) x 1000 (mg/g) = delivery rate (mg/min)
3. System influent flow (gpm) x 3.78 L/gal. = flow rate (L/min)
4. Delivery rate (mg/min) / flow rate (L/min) = dose rate in mg/L = ppm

When the LMI calibrations are complete, verify the valve on the chitosan storage tank is open and the valve on the calibration cylinder is closed. Verify that all LMI pumps are on.

Record the dose rate of the pretreat pump and the sand filter pump separately. Add these two dose rates together to get the overall system dose rate. The overall system dose rate should not exceed the maximum allowable chitosan dose rate (1 ppm).

***** The desired dose rate depends on many variables including site and system history, turbidity levels, use level designation limits, water chemistry, flow rate and pre-treatment activity. Typically an operator should dose the minimum amount necessary to achieve the desired result.

3.11 RESIDUAL CHITOSAN TEST

High doses of chitosan in the aquatic environment have exhibited toxic effects on fish in laboratory tests. In the CESF process, the majority of the chitosan introduced into stormwater is consumed during the coagulation/flocculation process. The residual chitosan test was developed to confirm the concentration of chitosan in the treated effluent is below the 0.2mg/L environmental threshold. The residual chitosan test is used as a precautionary measure to alert technicians of potential treatment problems before significant impacts can occur.

The Dept. of Ecology approves procedures for residual chitosan testing for each distributor of chitosan acetate. One example, “Colorimetric Determination of Residual Chitosan in Treated Stormwater”, is included as an attachment to this manual. The following procedure was produced as a quick reference for Clear Water technicians with considerations given to company specific equipment.

The use level designation require at least two discrete grab samples of CESF system discharge be analyzed for residual chitosan during each operating period. An operating period shall not exceed 24 hours. The samples must be collected one and two hours after the onset of each operating period.

3.11.1 Required Equipment

There should be two separate, clearly marked, sets of equipment. One set will be used for the sample analysis and should be marked “sample”. The second set will be for the matrix spike used for a color comparison. The second set should be marked “spike”.

- Two stir rods
- Two 140 mL capacity plastic syringes with threaded tip
- Two threaded plastic Swinnex filter seats
- Two plastic 1L beakers
- 1 pair of forceps
- plastic disposable droppers
- fiberglass micro filters
- Chemicals: 1% chitosan acetate, 0.1N solution Iodine, Sodium Bicarbonate (with scoop)

3.11.2 Procedure

Make sure all equipment is washed thoroughly and proper laboratory procedures are followed. Most “hits” produced in this test are actually false positives that are due to contaminated equipment.

1) Take 2 separate 1 liter samples from the sand filter effluent sample line.

2) Measure and record pH, turbidity and conductivity in the Residual Chitosan Test Monitoring Form. Transfer all relevant data from the LMI calibration to this form.

3) Add two drops of 1% chitosan acetate to the beaker marked “spike”. Stir vigorously for 1 minute to assure dissolution. This beaker now has a chitosan concentration of approximately 0.2 ppm.

4) Add one scoop (approximately 5 grams) each of Sodium Bicarbonate to the sample and the 0.1 ppm spike sample. Stir vigorously for one minute. Read and record the adjusted pH. The new pH level must be at 8 or above to cause the chitosan to come out of solution.

5) Open the Swinnex filter seats and carefully place clean filter papers in each one with a pair of forceps. Carefully thread the seats back together. Avoid cross threading the seats for proper filter dosing.

6) Draw 100 mL of the treated sample water from the “sample” beaker into the “sample” syringe. Thread the “sample” filter seat on to the syringe. Slowly push the sample water through the filter. Repeat with another 100 mL (200 mL total). Repeat procedure with “spike” sample.

7) Remove the filter seat from the syringe and then remove the filter from the seat with forceps. Remove the sample first and the spike second to avoid contamination.

8) Place each filter on a clean, inverted glass beaker to dry. Place the beaker a reasonable distance in front of a space heater to facilitate drying. Dry completely for optimum results.

9) After the filters are dry, add one drop of iodine to each filter. Wait 15 minutes to interpret results.

10) A light yellow rust color indicates the absence of chitosan. This is how the sample should appear. A dark brown or blue/black color indicates the presence of chitosan. This is how the spike sample should appear.

If an operator gets a positive test the system will immediately be shut down and investigated to determine if any of the operating parameters are out of specification. The system can then be corrected and the filtrate retested to confirm the absence of chitosan in the treated filtrate.

3.12 SYSTEM DISCHARGE

After the inline water quality readings are within discharge limits and initial LMI pump calibrations have been performed, the CESF system is ready for stormwater discharge. Access the Main Screen on the PLC and press the “Valves Auto” button. This will prompt the system to open the discharge valve and close the automated recirculation valve. The system will continue to direct all water through the discharge line as long as the pH and turbidity readings are within the programmed discharge limits.

The automated valves should be visually inspected periodically to confirm proper operation. Valves that do not fully actuate pose potential safety and/or equipment damage concerns. The discharge point should be visually inspected periodically for possible erosion, especially during the initial periods of operation.

3.13 MANUAL DATA COLLECTION

Water quality and system operational data are automatically logged through the PLC during periods of operation. In addition, operators should manually record system data every 15 minutes during operation. The Manual Data Collection Monitoring Forms are provided for this purpose.

These forms are designed to record influent and effluent data for pH, turbidity and sand filter pressures. Each sample recorded should be initialed by the operator logged in military time. An extra column is provided to make any relevant notes associated with each sample recorded.

As previously noted in section 3.5 Sensor Calibration, the Confidence Checks should be recorded in this form. This needs to be performed two times during every operational period. Immediately after a manual data record is taken, the system operator will obtain a grab sample from the sample influent and effluent lines. Turbidity and pH data is to be taken with the hand held meters and logged immediately below the inline meter data for comparison. Readings taken from the mechanical pressure gauges on the sand filter will recorded and compared with the readings on the PLC. An asterisk should be placed in the "Notes" field to indicate Confidence Check as described on the form.

3.14 BACKFLUSH

Backflushing is the process by which water flow is reversed through the sand beds to expel the accumulated sediment on the top of the beds. Each sand pod is flushed one at a time while the rest of the pods in the filter continue to operate normally. The stormwater which was filtered from the active pods will fill the bottom header and a portion of it is forced upward through the pod that is being backflushed.

Although backflush cycles are automated, the process needs to be understood and controlled by the system operator. The backflush parameters are set from the control box which is fixed to the side of the sand filter. Flush duration, delay between switching pods, manual start and stop as well as power and breaker switches are all on the control box. The cycle timer knob should be set to zero as backflush cycle initiation is typically controlled through the pressure differential switch on the bottom of the control box.

Typically, at a pre-set pressure differential, the controller will initiate a backflush cycle to remove the captured floc from the media bed. As the filter beds become clogged with floc particles the pressures between the top and bottom headers begin to deviate. The top header will gain pressure and the bottom header will lose pressure due to decreased water passage. When this pressure differential reaches a set level, the system will initiate the backflush cycle. The differential is generally set around 8 psi but will vary from system to system.

The system requires a minimum of 20 psi effluent pressure for adequate backflush. Pressures below this will generally not be high enough to fluidize the sand beds, which is necessary for proper backflush. System pressures and flow rates will differ between operation and backflush cycles. Operators must monitor flows and pressures during transition to backflush to assure they remain optimal. Valve adjustments may need to be made accordingly. In addition to the influent and effluent control valves there is a valve at the end of the backflush header. This valve is set during system start up to optimize backflush flow without discharging filter media. This backflush valve generally does not need adjusting and should only be adjusted by experienced operators who are familiar with that particular site.

A site glass is installed at the top of the backflush header to monitor backflush efficiency. The water in the site glass should appear turbid during the initial stage of each pod flush. Toward the end of the flush the water should appear clearer as all of the floc is expelled from the sand bed. Some systems are equipped with backflush sample lines which can also be used to monitor the effectiveness of the backflush. Flush duration should be set at two minutes. To increase backflush intensity, operators should increase the frequency instead of duration of the cycle.

The consequence of insufficient backflushing is impacted sand beds. Failure to backflush will cause excess floc accumulation in the filter. Excess floc under operating pressures will cause the beds to compact, limiting water movement through the beds. This is commonly called impaction. Impaction will force a system shut down. The water in the filter must be evacuated, the filters will need to be opened and the sand in the filter must be broken up with a shovel. In extreme cases the filter medium may be so compromised that it will need to be discarded and replaced.

3.15 SYSTEM SHUT DOWN

System operation is typically carried out during pre determined shifts. System operations may need to be abbreviated or extended based on retention pond levels or predicted rain events. Occasionally, shifts will be extended on an emergency basis if there is danger of potential site release.

Shut down procedures will vary from site to site. Project Managers should communicate site specific concerns directly to technicians or through site documents. The following checklist covers the range of typical tasks that need to be completed when shutting down a CESF system.

1) Switch pneumatic valve from “auto” to “recirc” by pressing “Recirc Valve On” on the PLC.

2) Switch LMI pumps off on the PLC.

3) Switch pretreat and main pump off on the PLC.

4) Visually and audibly confirm pump shut down.

5) Record final totalizer readings on the daily operations form. Record any operational anomalies your PM may be concerned about. Record system operation assessment and certify acceptability of operation. Communicate significant system upsets or concerns directly to the PM.

6) Finish all paper work. Remove the pink slips from the operations form and place in the appropriate folder. Return remaining copies to the PM.

7) Drain air compressor.

8) Clean laboratory bench top and system container.

9) Close chitosan tank valve. Close sample port valves. Open sand filter bleeder valves to aid the drainage of the sand filter.

10) Empty, rinse and replace inline cuvettes. Remove and clean inline pH probes. Immerse probes in proper storage solution.

11) Perform any necessary freeze protection procedures. Leave heaters, container and generator switches in “Auto”

12) Switch sensors off on the PLC. Close automatic valves on the PLC.

13) Turn off all lights and any extraneous power from the container.

14) Secure the site and lock the system. Any valuable equipment should be locked up to discourage theft.

Clear Water staff should leave all PPE on until they have entered their vehicle to leave the site. All Clear Water trucks are supplied with magnetic amber lights which should be attached to the top of the vehicle and activated until the vehicle has exited the construction site. Yield to all heavy equipment when driving on construction sites. Obey all traffic control instructions. Construction sites are inherently dangerous places and Clear Water employees should exercise extreme caution when present.

CONTROL SYSTEM OPERATION

This section is designed to teach Clear Water technicians how to use the control interface for the CESF systems. This is dedicated to the control system operations and does not include operating procedures for the mechanical parts of the system. The control system is commonly referred to as the programmable logic controller (PLC). The system is designed to simplify technician procedures while ensuring compliance with regulatory requirements for CESF operations

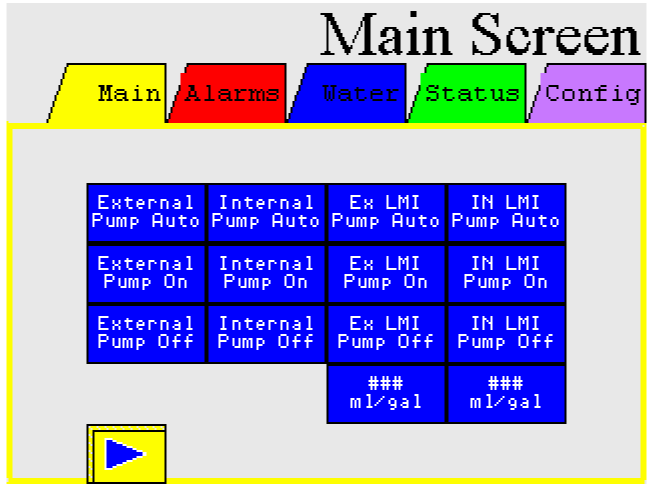
4.1 TOUCH SCREENS

When the touch screen first comes on it will display the alarm screen. Given that multiple alarms (of the same or different types) could have occurred since the last time the system was operational, a series of alarms may need to be acknowledged. Acknowledge alarms by pressing the “Ack All” button. Be sure to check the Alarm Screen before you begin operations.

Once all the alarms are acknowledged, the Logo (or Startup) screen will appear. This screen is for informational purposes only. Touch the “Main” button to access into the operational screens of the program.

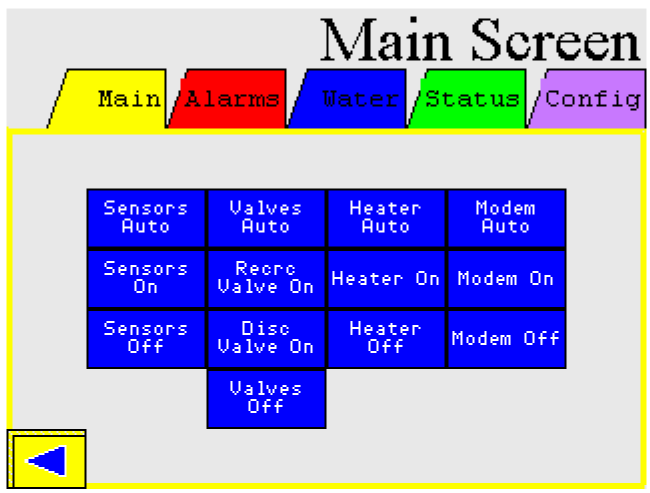
The screens are color coded and can be accessed by the file tabs at the top of the screen. The types of screen are; Main, Alarm, Water, Status, and Configuration.

"Main" screens are where system control takes place. There are two "Main" screens, for operations. The "Main" screens are laid out in a columnar fashion. The top button on each column puts that component into Automatic mode governed by the specific operational parameters that have been preset for it. The "On" button turns that component on with all safety and internal checks overridden for that particular component. The "Off" button disables that component. The primary main screen controls all system pumps.



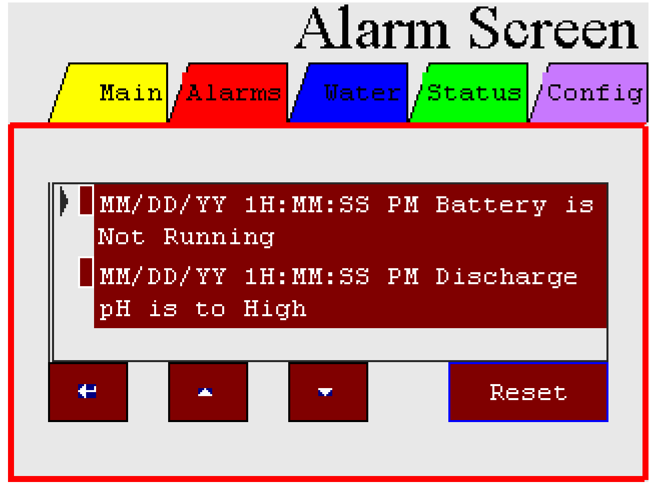
The yellow and blue arrow button at the bottom of the screen lets operators to toggle back and forth between the two main screens.

The secondary main screen controls system sensors, automated discharge valves, heaters and the system modem. In most situations the modem and heater controls should always be left in "Auto". These buttons will change state based on what the PLC is trying to do not necessarily what the system is actually doing. *Example: You push the button to open the Discharge Valve but there is no air pressure. The PLC is trying to open the valve so the display will blink "Disc Open" yet the valve is still closed.*



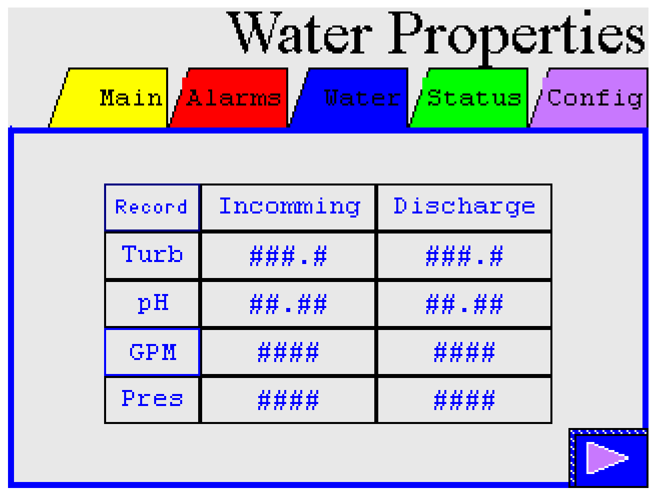
Some sites may not have some components. In such cases columns identifying unused components will be blank.

The “Alarm” screen displays emergency status information requiring immediate attention. All alarms on this screen that contain the word “Faulted” have to be cleared using the “Reset” button and are impeding operation of the system in some fashion. Alarms that do not contain “Faulted” warnings are for information only and do not require manual reset.

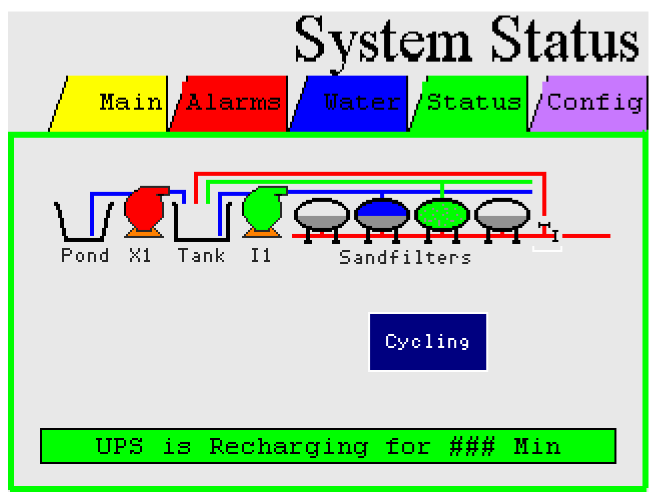


The “Water” screen is designed to display the water quality and system hydrology data. The data in the left hand column displays influent data and the column on the right displays effluent data. It alternates between current data and the running system recordable data. To know which you are looking at see the top left hand corner of the matrix.

The arrow button in the lower right hand corner will take you to the “Last Saved” screen.



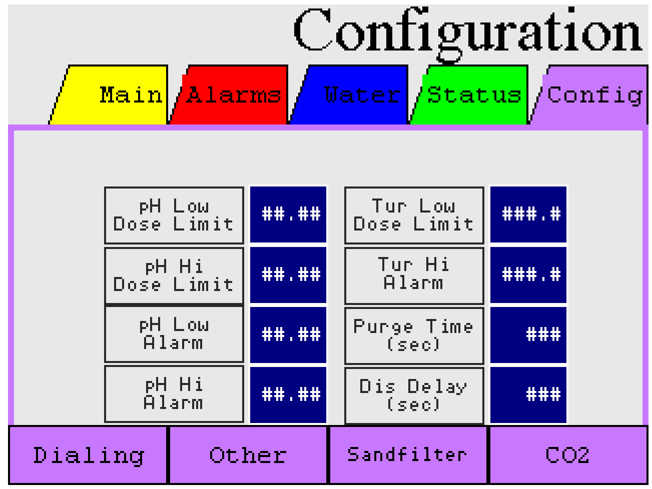
The “Status” screen is a graphical display that is designed to give the operator a real-time flow diagram of system operations.
The water level in the “Pond” and “Tank” corresponds to the actual levels in those facilities. Pumps are green for on and red for off, with a large X indicating a fault. The sand filter modules change from gray, off; to blue, on; to green, back flush. The valves will change direction based on the current status of the system.



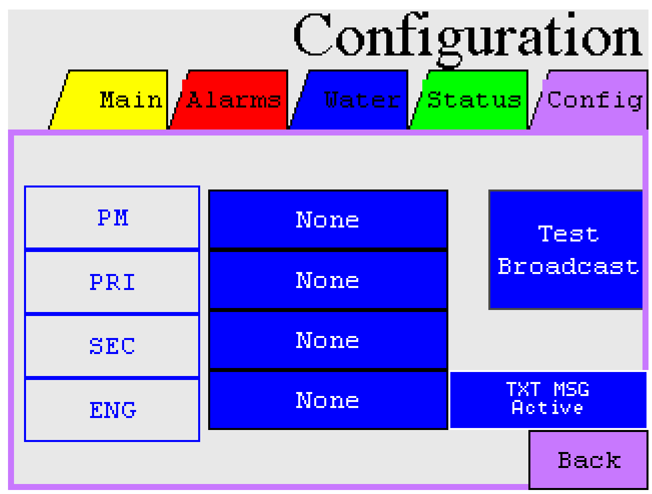
The main configuration screen sets the discharge limits for that particular site. These limits are preset and should not be changed by operators.

The pH and turbidity alarms identify the meter readings which will display visual alarms on the stop system discharge.

“Dis Delay” is the amount of time the treated water must be within spec before the PLC will allow discharge during automatic operation.



The second configuration screen is used to select emergency text message recipients. Each one allows you to cycle through the list of possible recipients just by touching the name multiple times. Four individuals can be selected Project Manager, Primary Responder, Secondary Responder, and Engineer. This screen also contains a test broadcast button. This allows you to test the text message system. If “None” is selected in a given box the PLC will skip that individual to call.



4.2 ALARM GLOSSARY

Discharge pH is too High: The discharge pH reading the PLC is receiving from the pH meter on the discharge header is greater than the pH Hi Alarm value set in the configuration screen.

Discharge pH is too Low: The discharge pH reading the PLC is receiving from the pH meter on the discharge header is lower than the pH Low Alarm value set in the configuration screen.

Discharge Turbidity is too High: The discharge Turbidity reading the PLC is receiving from the Turbidity meter on the discharge header is greater than the Turbidity Hi Alarm value set in the configuration screen.

Tank Level is too High: PLC is receiving a signal from the Tank High Level float switch, or the value from the Tank Level transducer is reading higher than the preset high limit.

Pond Level is too High: PLC is receiving a signal from the Pond High Level float switch, or the value from the pond Level transducer is reading higher than the preset high limit.

System in Recirculation Mode: PLC has actuated the recirculation valve to Open.

UPS Power is Low: Generator is operational for the purpose of recharging the UPS.

Generator Faulted Out: PLC sent a signal for the Generator to auto start but has not received a power on signal in 30 seconds.

Pond Operate Switch Faulted: High Level Pond switch is triggered but the Operate switch is not.

Pond Low Level Switch Faulted: Operate Level Pond switch is triggered but the Low Level switch is not.

Tank Operate Switch Faulted: High Level Tank switch is triggered but the Operate switch is not.

Tank Low Level Switch Faulted: Operate Level Tank switch is triggered but the Low Level switch is not.

Internal Pump Faulted: PLC sent a start signal to the Soft Started and has not received an Up to Speed signal back for 30 seconds.

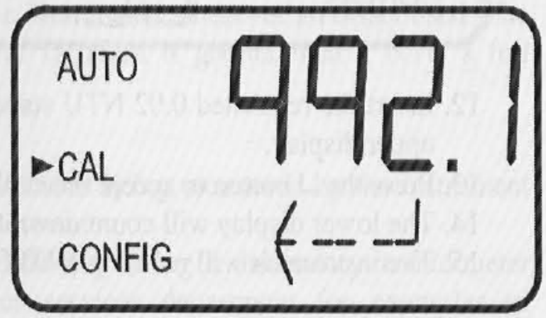
External Pump Faulted: PLC sent a start signal to the Motor Contactor and has not received an operational signal back for 30 seconds.

Max Pressure Exceeded: One of the Pressure Transducers sent a signal to the PLC that exceeded the 60 PSI Maximum Pressure Setting and shut down the Pumps.

ATTACHMENTS

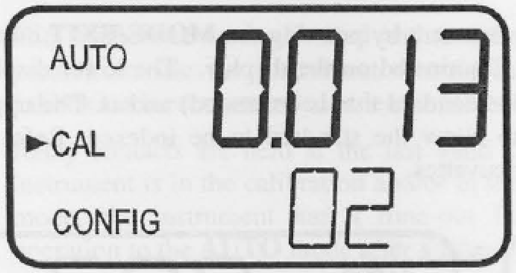
5.2 Calibration Procedures

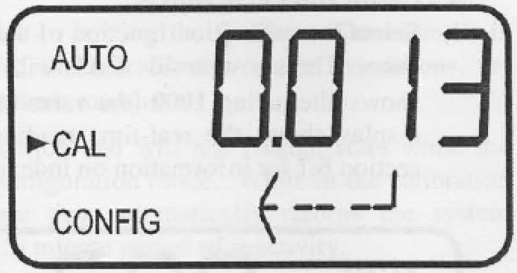
1. Select the calibration function of the instrument by pressing the **MODE/EXIT** button once. The arrow beside **CAL** will be illuminated on the display. The lower display shows alternating **1000** (the value of the standard that is requested) and ↵. The upper display shows the real-time reading to allow the standard to be indexed. Refer to section 6.1 for information on indexing cuvettes.



2. Remove the flow through unit.
3. Insert the requested 1000 NTU standard. Index the standard to the lowest value on the upper display.
4. Press the ↵ button to accept the calibration.
5. The lower display will count down the progress of the calibration step.
6. The lower display will now change to show alternating **10** and ↵, requesting the 10.0 NTU standard.

7. If the alternating **10** and ↵ is not displayed, push the ▲ or ▼ until this display is shown.
8. Insert the requested 10.0 NTU standard. Index the standard to the lowest value on the upper display.
9. Press the ↵ button to accept the calibration.
10. The lower display will count down the progress of the calibration step.
11. The lower display will now change to show **02** and ↵, requesting the 0.02 NTU standard.



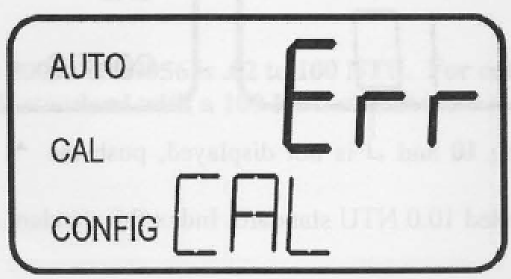


12. Insert the requested 0.02 NTU standard. Index the standard to the lowest value on the upper display.
13. Press the ↵ button to accept the calibration.
14. The lower display will count down the progress of the calibration step.
15. The instrument will return to **AUTO** mode at the end the calibration.

Note: During calibration, the fan inside the instrument is turned off to extend the life of the desiccant. The fan will be turned on during calibration countdowns and after returning to the AUTO mode or after five minutes, which ever comes first. It is recommended that the measurement chamber be kept covered during the calibration period and that the flow through cuvette be replaced immediately after the calibration to prevent premature saturation of the desiccant.

5.3 Calibration Error

If the screen shown below, is displayed after calibration, the internal diagnostics have determined that the calibration standards were either bad or that they were inserted in the wrong order. Either check the standards and recalibrate or restore the factory calibration see 6.2 *Restoring Factory Settings*. The instrument cannot be used without performing one of these operations.



To recalibrate press the MODE key and start the calibration sequence again. To restore the factory calibration, push and hold the ▲ button. Now push and release the ↵ then release the ▲ button.

EASY CAL Procedure - pH

- This procedure simplifies system calibration using standard 4.0, 7.0, 10.0 pH buffers only. If these pH buffers are not available, calibrate the system via the CALIBRATE menu, using the STANDARD and SLOPE settings.
- Access the CALIBRATE menu and set sensor temperature before performing EASY CAL for new electrode installations.
- Access EASY CAL menu from the view menu.

EASY CAL: ---- Enter Key Code	Press UP, UP, UP, DOWN buttons in sequence to enter menu, XXXX will appear during code entry.

To Calibrate:	Response:	To Accept:
Place Sensor in pH Buffer #1 Place electrode tip in first pH buffer pH 7.0 = 0 mV pH 4.0 = 177 pH 10 = -177 Limit ± 60 mV	6.90 pH -005 mV Allow for stabilization 30 seconds*	6.90 pH -005 mV ENTER to accept 7.00 pH -005 mV
Place Sensor in pH Buffer #2 Place electrode tip in second pH buffer. 2	3.93 pH +179 mV Allow for stabilization 30 seconds*	3.93 pH +179 mV Press ENTER to accept second buffer calibration. 4.00 pH +179 mV
To exit menus and return to VIEW press UP and DOWN button at the same time	Display returns to VIEW Menu in 10 minutes or when ENTER is pressed	Good Easy Cal Press <ENTER>

Theoretical mV values

pH @ 25°C	mV
2	+296
3	+237
4	+177
5	+118
6	+59
7	+0
8	-59
9	-118
10	-177
11	-237
12	-296

Colorimetric Determination of Residual Chitosan in Treated Stormwater[1]

Field Test

Background Chitosan-Enhanced Sand Filtration has proven to be a safe and effective treatment technology for the purification of construction stormwater. Chitosan has been tested extensively to determine its aquatic toxicity and stormwater treated with chitosan has also been tested and found to have no effect on fish and daphnia. Because concentrated chitosan does exhibit significant toxic effects on rainbow trout in clean laboratory water, it is important to know if there is chitosan in the stormwater after treatment and filtration. A review of the 15th edition of Standard Methods and EPA's test method manual (SW-846) revealed no test methods for low-level chitosan acetate analysis in water. 10 major analytical laboratories were consulted also and none were able to test for low-levels of chitosan acetate. Consequently, the following colorimetric iodine spot field test for the semi-quantitative analysis of chitosan has been developed.

It is important to note that this is a <u>screening field test</u> which is used to alert the treatment system operator in the event of a positive test result. This test is only designed to detect the presence of greater than 0.10 mg/L (100 µg/L) chitosan in the treated filtrate, not to quantify that presence. If an operator gets a positive test the system can then be investigated to determine if any of the operating parameters are out of specification. The system can then be corrected and the filtrate retested to confirm the absence of chitosan in the treated filtrate. This is the purpose of the test.

1. PRINCIPLE AND APPLICABILITY

Principle. This method is based on the well-known reaction between iodine and polysaccharides (chitosan is a natural polysaccharide). When iodine is added to a chitosan sample the original iodine yellow-rust color will change to a deep blue-black color indicating the presence of a polysaccharide (see Figures 1 and 2). The chitosan used for water treatment (Storm Klear Liqui-Floc) is fully water-soluble chitosan acetate (chitosan dissolved in a 5% solution of acetic acid). This test methodology requires the precipitation of residual chitosan acetate (in the sample) with sodium bicarbonate with subsequent filtration to capture the precipitated chitosan on a one-inch diameter glass fiber micro filter. Because the residual chitosan concentration is estimated to be less than 0.1 mg/L in treated filtrate, 200 mL of water must be filtered through the one-inch diameter glass fiber micro filter. Because the residual chitosan concentration is estimated to be less than 0.1 mg/L in treated filtrate, 200 mL of water must be filtered through the one-inch

diameter glass fiber micro filter in order to concentrate enough chitosan to react with the iodine (a minimum of 20 micrograms). The pH of the water sample is increased to > 8 to precipitate any chitosan present[2].

After filtration, the filter paper is used for the colorimetric test (one drop of iodine is placed on the filter paper). This test is semi-quantitative and is designed only to confirm the absence of chitosan in stormwater treated with chitosan. There is no way to determine

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[1] Analytical test method developed by JW Macpherson, Natural Site Solutions LLC

[2] Chitosan acetate precipitates at pH 8 and above - Vanson HaloSource, Inc. 2004

the exact concentration of chitosan in the event of a positive reaction except to estimate >0.1 mg/L.

1.2 Applicability. This method is applicable for the semi-quantitative analysis of chitosan in stormwater treated with chitosan. It has been developed as a field test that can be quickly and easily performed in a contractor's trailer on a construction site.

2. RANGE AND SENSITIVITY

The lower limit of detection is approximately 0.1 mg/L (0.1 ppm) with a water sample volume of 200 mL. The maximum of the range is essentially unlimited.

3. INTERFERENCES

3.1 Polysaccharides other than chitosan (such as guar) have the potential to interfere by false positive. Interferences may be screened by testing the influent water for polysaccharides prior to treatment. Chitosan is the only polysaccharide introduced to the treatment system. Based on field experience, polysaccharides are not present in natural waters or stormwater detention basins at a concentration high enough to interfere with this test method.

3.2 Another potential interference is the accumulation of dirt particles on the glass fiber filter. To reduce this problem the water to be tested (treated filtrate) must be 10 NTU or less. Chitosan-enhanced sand filter systems typically produce treated filtrate less than 10 NTU.

4. PRECISION AND ACCURACY

See QA/QC section.

5. APPARATUS

5.1 Sampling Apparatus.

5.1.1 Sampling Containers. Clean 1,000 mL plastic containers.

5.2 Sample Filtration.

5.2.1 Glass Fiber Filter. (1) 140 mL capacity plastic syringe with threaded connector to attach *Swinnex* filter holder. (1) 25 mm filter holder (Swinnex plastic filter holder) http://www.wine-testing-supplies.com/cgi-bin/cp-app.cgi
(1) box of 100 Ahlstrom (or equivalent) glass microfiber filters
(See Figure 6)

6. REAGENTS

6.1 Sampling.

6.1.1 Sample Preservation. None required as water will be analyzed immediately.

6.3 Analysis.

6.3.2 Caustic Food-grade sodium bicarbonate powder

6.3.3 Iodine 0.10 N solution as I_2, CAS# 7553-56-2

6.3.4 Chitosan 1% solution of chitosan acetate as a standard (Vanson).

7. PROCEDURE

7.1 Sampling.

7.1.1 Collect (2) 1 Liter samples of the chitosan-treated filtrate directly from the effluent of the chitosan-enhanced sand filter system. Test with a turbidimeter to ensure the turbidity is less than 10 NTU.

7.2 Sample Filtration.

7.2.1 Adjust the pH of the prefiltered sample to > 8 with sodium bicarbonate (approx. 5 grams) and mix for 1 minute. Then filter 200 mL of the sample through the 25 mm glass fiber filter unit attached to the filtration syringe (see Figure 6).

7.3 Analysis.

7.3.1 Air-dry the 25mm glass fiber filter3. Put one drop of iodine on the dried filter paper, wait 15 minutes then interpret the results. A light yellow-rust color indicates the absence of chitosan (<0.1 mg/L). A dark brown or blue/black color indicates the presence of chitosan (>0.1 mg/L). See Figures 3 and 4 for color key. It is important to note that the iodine color associated with a negative result (or blank) will fade and disappear within about 20 minutes while the color associated with a positive test is permanent for a period of several hours at least. Figure 5 is a color comparison chart using actual treated filtrate with a turbidity of 9.05 NTU.

7.4 Field Matrix Spike. To the second 1-liter sample add chitosan acetate standard to a concentration of 0.10 mg/L and repeat the filtration procedure. Put one drop of iodine on the dried filter paper, wait one minute then interpret the results. This spike should be recovered as a dark stain on the filter paper (see Figures 3 and 4).

8. CALIBRATION – QA/QC

8.1 Method Calibration (Laboratory Spikes, blanks and duplicates).

8.1.1 To calibrate the test method run the test sequence using laboratory grade water with four different known concentrations of chitosan acetate as indicated below:

0 mg chitosan acetate in 1 liter water (0.0 mg/L) the blank
0.125 mg chitosan acetate in 1-liter water (0.125 mg/L)
0.25 mg chitosan acetate in 1-liter water (0.25 mg/L)

[3] The glass micro-fiber filter does not have to be completely dry but should be nearly dry or completely dry to obtain the best results.

0.5 mg chitosan acetate in 1-liter water (0.5 mg/L)

Adjust the pH of each test solution to 8.0 or greater with 5 grams sodium bicarbonate, mix and let stand for 5 minutes. Filter 200 mL of each solution, remove and dry the filter, then add one drop of the iodine solution to each filter and observe the result.

Wait 15 minutes then interpret the results[4]. The control blank should be colorless or nearly colorless while the 0.125 mg and 0.25 mg and 0.5 mg standards should turn dark brown, or nearly black (see Figures 3 and 4).

8.1.2 Re-run the tests using new standards – test duplicates.

9. Method QA/QC

9.1 Matrix Spikes.

Collect one liter of treated CESF effluent known to be free of residual chitosan. To each sample add:

0 mg chitosan acetate in 1 liter water (0.0 mg/L)
0.125 mg chitosan acetate in 1-liter water (0.125 mg/L)
0.25 mg chitosan acetate in 1-liter water (0.25 mg/L)
0.5 mg chitosan acetate in 1-liter water (0.5 mg/L)

Adjust the pH of each test solution to 8.0 or greater with 5 grams sodium bicarbonate, mix and let stand for 5 minutes. Filter 200 mL of each solution, remove and dry the filter, then add one drop of the iodine solution to each filter and observe. See Figure 5.

9.2 Matrix Spike Duplicates.

Collect one liter of treated CESF effluent known to have less than 0.1 mg/l residual chitosan. To each sample add:

0 mg chitosan acetate in 1 liter water (0.0 mg/L)
0.125 mg chitosan acetate in 1-liter water (0.125 mg/L)
0.25 mg chitosan acetate in 1-liter water (0.25 mg/L)
0.5 mg chitosan acetate in 1-liter water (0.5 mg/L)

Adjust the pH of each test solution to 8.0 or greater with 5 grams sodium bicarbonate, mix and let stand for 5 minutes. Filter 200 mL of each solution, remove and dry the filter, then add one drop of the iodine solution to each filter and observe.

[4] After approximately 20 minutes the yellow-rust color of the iodine without chitosan (blank) will disappear leaving no color (see Figures 3 &4). The dark color of iodine in the presence of chitosan will persist and become permanent.

9.3 Blanks.

Blanks should be run along with the treated water sample to ensure there is no inadvertent chitosan contamination in the equipment. To perform a blank analysis, adjust the pH of distilled water to > 8 with sodium bicarbonate and filter in exactly the same way the sample is filtered. Place one drop of the iodine solution on the dried filter element. The blank should be a yellow-rust color with no visible dark staining and the color should fade to colorless within approximately 15 to 20 minutes leaving a white filter.

The above QA/QC tests were run and the colorimetric results were photographed in Figures 2, 3, 4 and 5. The results indicate that:

- **Figure 2 demonstrates a definite chitosan/iodine colorimetric reaction.**
- **Blanks and blank duplicates showed no color response, as expected.**
- **Laboratory spikes (Figures 3 and 4) showed a good color response at the lowest concentration of 0.125 mg/L and the spike duplicates showed similar color intensities.**
- **Matrix spikes in treated filtrate (Figure 5) showed a good color response at the lowest concentration of 0.125 mg/L.**

ATTACHMENT 2

Chitosan-Enhanced Sand Filtration Operation Forms

CLEAR WATER COMPLIANCE SERVICES, INC.

CESF – DAILY SYSTEM OPERATIONS AND MAINTENANCE

Project Title: ______________________ Project No.: ____________

Project Location: ______________________ Date: ____________

Weather Conditions: ______________________

	Pretreatment Meter Reading		Influent Meter Reading		Effluent Meter Reading	
	Gallons	Time	Gallons	Time	Gallons	Time
Start:	________	______	________	______	________	______
Finish:	________	______	________	______	________	______
Total Volume:	____________		____________		____________	

Operator's Evaluation of System Operations: ______________________

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Residual Chitosan Test: # of tests: ________ Results: # Passed ______ # Failed ______

Recent Hydroseeding/Hydromulching onsite: Yes No

First Shift	**Second Shift**	**Third Shift**
____________________	____________________	____________________
Technician Name	Technician Name	Technician Name
____________________	____________________	____________________
Technician Signature	Technician Signature	Technician Signature

CLEAR WATER COMPLIANCE SERVICES, INC.

CESF – EVALUATION OF SYSTEM OPERATIONS & MAINTENANCE

Project Title: ______________________________ Project No.: ____________

Project Location: ______________________________ Date: ____________

Operator's Evaluation of System Operations: ______________________________

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Other Monitoring: ______________________________

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First Shift	**Second Shift**	**Third Shift**
____________	____________	____________
Technician Name	Technician Name	Technician Name
____________	____________	____________
Technician Signature	Technician Signature	Technician Signature

CLEAR WATER COMPLIANCE SERVICES, INC.

MANUAL DATA COLLECTION MONITORING FORM

Project Title: ______________________________ Project No.: ______________

Project Location: ______________________________ Date: ______________

Notes	Time	pH Influent / Effluent	NTU Influent / Effluent	Pressures Influent / Effluent	Initials
		/	/	/	
		/	/	/	
		/	/	/	
		/	/	/	
		/	/	/	
		/	/	/	
		/	/	/	
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		/	/	/	
		/	/	/	

* Indicates verification of in-line meters – samples measured with benchtop meters (required once per day).

First Shift	Second Shift	Third Shift
Technician Name	Technician Name	Technician Name
Technician Signature	Technician Signature	Technician Signature

CLEAR WATER COMPLIANCE SERVICES, INC.

CESF SYSTEM INSTRUMENT CALIBRATION REPORT FORM

Project Title: ______________________________ Project No.: ____________

Project Location: ______________________________ Date: ____________

Influent pH Meter Model: ______________________________

pH Standard: __________ Initial Reading: __________ Calibrated Reading: __________

pH Standard: __________ Initial Reading: __________ Calibrated Reading: __________

Effluent pH Meter Model: ______________________________

pH Standard: __________ Initial Reading: __________ Calibrated Reading: __________

pH Standard: __________ Initial Reading: __________ Calibrated Reading: __________

__________ pH Meter Model: ______________________________

pH Standard: __________ Initial Reading: __________ Calibrated Reading: __________

pH Standard: __________ Initial Reading: __________ Calibrated Reading: __________

__________ pH Meter Model: ______________________________

pH Standard: __________ Initial Reading: __________ Calibrated Reading: __________

pH Standard: __________ Initial Reading: __________ Calibrated Reading: __________

First Shift	**Second Shift**	**Third Shift**
Technician Name	Technician Name	Technician Name
Technician Signature	Technician Signature	Technician Signature

CLEAR WATER COMPLIANCE SERVICES, INC.

CESF SYSTEM INSTRUMENT CALIBRATION REPORT FORM

Project Title: ______________________________ Project No.: ____________

Project Location: ______________________________ Date: ____________

Pretreatment Turbidity Meter Model: ______________________________

Turbidity Standard: __________ Initial Reading: __________ Calibrated Reading: __________

Turbidity Standard: __________ Initial Reading: __________ Calibrated Reading: __________

Turbidity Standard: __________ Initial Reading: __________ Calibrated Reading: __________

Influent Turbidity Meter Model: ______________________________

Turbidity Standard: __________ Initial Reading: __________ Calibrated Reading: __________

Turbidity Standard: __________ Initial Reading: __________ Calibrated Reading: __________

Turbidity Standard: __________ Initial Reading: __________ Calibrated Reading: __________

Effluent Turbidity Meter Model: ______________________________

Turbidity Standard: __________ Initial Reading: __________ Calibrated Reading: __________

Turbidity Standard: __________ Initial Reading: __________ Calibrated Reading: __________

Turbidity Standard: __________ Initial Reading: __________ Calibrated Reading: __________

First Shift	**Second Shift**	**Third Shift**
Technician Name	Technician Name	Technician Name
Technician Signature	Technician Signature	Technician Signature

CLEAR WATER COMPLIANCE SERVICES, INC.

BENCHTOP INSTRUMENT CALIBRATION REPORT FORM

Project Title: ____________________ Project No.: ____________

Project Location: ____________________ Date: ____________

pH Meter Model: ______________________________

pH Standard: __________ Initial Reading: __________ Calibrated Reading: __________

pH Standard: __________ Initial Reading: __________ Calibrated Reading: __________

pH Standard: __________ Initial Reading: __________ Calibrated Reading: __________

Turbidity Meter Model: ______________________________

Turbidity Standard: __________ Initial Reading: __________ Calibrated Reading: __________

Turbidity Standard: __________ Initial Reading: __________ Calibrated Reading: __________

Turbidity Standard: __________ Initial Reading: __________ Calibrated Reading: __________

Turbidity Standard: __________ Initial Reading: __________ Calibrated Reading: __________

Conductivity Meter Model: ______________________________

Conductivity Standard: __________

Initial Reading: __________

Calibrated Reading: __________

First Shift	Second Shift	Third Shift
Technician Name	Technician Name	Technician Name
Technician Signature	Technician Signature	Technician Signature

CLEAR WATER COMPLIANCE SERVICES, INC.

CHEMICAL METERING PUMP CALIBRATION FORM

Project Title: ______________________________ Project No.: ____________

Project Location: ______________________________ Date: ____________

Note: Chemical metering pump calibrations are required at the start of treatment system operations and every 4 hours following treatment system startup.

Time	Pre-treat/ Sand Filter	Flow (gpm)	Chitosan 1% or 2%	Chitosan Delivery (ml/min)	Dose Rate (ppm)	Initials

CHITOSAN DELIVERY DOSE RATE CALCULATION

1. Liqui-Floc delivery rate (ml/min) x 0.01 (chitosan concentration) x 1 g/ml (weight of liqui-floc) = absolute weight of chitosan in g/min
2. Chitosan delivery (g/min) x 1000 mg/g = chitosan delivery rate (mg/min)
3. System influent flow (gpm) x 3.78 L/gal. = stormwater flow rate (L/min)
4. (Chitosan-mg/min) / (flow rate-L/min) = dose rate in mg/L = ppm

First Shift	**Second Shift**	**Third Shift**
Technician Name	Technician Name	Technician Name
Technician Signature	Technician Signature	Technician Signature

CLEAR WATER COMPLIANCE SERVICES, INC.

RESIDUAL CHITOSAN TEST MONITORING FORM

Project Title: ______________________________ Project No.: ______________

Project Location: ______________________________ Date: ______________

Note: Residual chitosan testing is required twice during the first two hours of each 8 hour operational period.

Sample Time	Turbidity NTU	pH	Specific Conductance µS/cm	Flow Rate gpm	Chitosan Delivery ml/min	Chitosan Dose Rate ppm

RESIDUAL CHITOSAN TEST No. 1 – ANALYSIS – Time

pH Start ____________ Adjusted pH ____________ Test Result: Positive Negative

RESIDUAL CHITOSAN TEST No. 1 – MATRIX SPIKE - Time

pH Start ____________ Adjusted pH ____________ Test Result: Positive Negative

Residual Chitosan Test Results: Pass Fail

RESIDUAL CHITOSAN TEST No. 2 – ANALYSIS - Time

pH Start ____________ Adjusted pH ____________ Test Result: Positive Negative

RESIDUAL CHITOSAN TEST No. 2 – MATRIX SPIKE – Time

pH Start ____________ Adjusted pH ____________ Test Result: Positive Negative

Residual Chitosan Test Results: Pass Fail

First Shift	**Second Shift**	**Third Shift**
Technician Name	Technician Name	Technician Name
Technician Signature	Technician Signature	Technician Signature

CLEAR WATER COMPLIANCE SERVICES, INC.

RECEIVING WATER QUALITY MONITORING FORM

Project Title: ______________________ Project No.: ____________

Project Location: ______________________ Date: ____________

Before Startup:

Sample Location: ______________________

	Upstream	Downstream
Sample Time:	____________	____________
Turbidity (NTU):	____________	____________
pH (Standard Units):	____________	____________
Specific Conductance (uS/cm):	____________	____________

During Operations:

Sample Location: ______________________

	Upstream	Downstream
Sample Time:	____________	____________
Turbidity (NTU):	____________	____________
pH (Standard Units):	____________	____________
Specific Conductance (uS/cm):	____________	____________

First Shift	**Second Shift**	**Third Shift**
Technician Name	Technician Name	Technician Name
Technician Signature	Technician Signature	Technician Signature

CLEAR WATER COMPLIANCE SERVICES, INC.

BENCH-SCALE TREATABILITY DOCUMENTATION FORM

Project Title: ______________________________________ Project No.: ____________

Project Location: ____________________________________ Date: ______________

Sample Identification: ____

Sample Time: ____________ Sample Volume: ____________ Turbidity (NTU): __________

pH initial (Std. units): ____________ pH (Std. units): ____________ Conductivity (μS/cm): __________

(If normally adjusted using CO_2 or Sodium Bicarbonate)

Bench-Scale Treatability Results

Drops of 1% Liqui-floc	Estimated Dose Rate (ppm)	Observed Results (floc size and setting time)

1 drop of 1% Liqui-Floc using a 3-mL transfer pipette is approximately 0.5 ppm in a 1-liter sample

1 drop of Poly Alum 60 using a 3-mL transfer pipette is approximately 37 ppm in a 1 liter sample

Observations: ____

____

____

____

First Shift	Second Shift	Third Shift
Technician Name	Technician Name	Technician Name
Technician Signature	Technician Signature	Technician Signature

APPENDIX E

Backup Calculations and Specifications

HYDRAULIC ANALYSIS
LONG-TERM STORMWATER TREATMENT
NORTH BOEING FIELD – SEATTLE, WASHINGTON

Weir Tank Analysis Calculations:

The following calculations were completed to evaluate the weir tank sizing and estimate the particle sizes likely to settle-out during system operation.
The weir tanks used in this treatment system include two under-over weir tanks of approximately 18,000 gallon capacity.
The inlet weir tank is designed to accommodate 1500 gpm of flow under normal conditions, and a peak flow of 2,000 gpm.

The backflush settling tank is similar in construction to the inlet weir tank. Design flow for the backflush settling tank is 239 gpm under normal conditions, and a peak flow of 600 gpm.

Method Summary:
The calculations include estimating settling velocities for particles of various size and density, and comparing the settling velocity to the overflow rate.
The overflow rate is based on the tank sizing, and provides a reasonable comparison of settling velocities to the anticipated residence time within the settling zone of the tank.
Various dimensions for the settling zone are evaluated to determine an appropriate size for the settling zone (determine baffle placement).

Estimations for various removal fractions are presented in Tables D-1 and D-2. The estimated removal fraction is based on the ratio of settling velocity to overflow rate.

Additional Notes:
The flow rate (and therefore fluid velocity) through the inlet weir tank is relatively high.
Therefore, for the purposes of this analysis and as a conservative estimation, we assume significant sedimentation is occuring only in the settling zone.
The design goal of the inlet weir tank is to remove particles to protect the downstream pump (P-301). The manufacturer's specification indicates the pump can handle particles up to 7/8-inch (2.2 cm) in diameter.
The flow rate through the backflush settling tank is low enough that settling is assumed to occur in a larger portion of the tank, as presented below.

Conclusions:

Inlet Weir Tank:
Based on the various settling velocities presented in Table D-1 and a settling zone length of 14.5 feet, the inlet weir tank should provide adequate sedimentation of suspended particles to protect downstream equipment (Pump P-301 in particular).

Backflush Settling Tank:

The backflush settling tank should be sufficient to remove particles greater than 0.001 cm in diameter with a typical specific gravity of 1.5. Because the particles in the backwash fluids have been treated with chitosan, we assume the minimum particle size removed by this settling tank is appropriate to limit significant particle and chitosan-loading of the inlet weir tank.

TABLE E-1
LONG-TERM STORMWATER TREATMENT
NORTH BOEING FIELD – SEATTLE, WASHINGTON

Settling Velocities

$$Vs = \sqrt{3.3 \cdot g \cdot (Ss - 1) \cdot d}$$

Vs = Settling Velocity
g = gravity = 9.8 m/s^2
Ss = Specific Gravity of Particles (variable 1.001 to 2.15)
d = Particle diameter (variable 0.4 to 10 cm)

Vs cm/sec	Vs ft/sec	Ss	d cm	% Removal (Design flow)	% Removal (Peak flow)
0.0001798	5.90004E-06	1.001	0.000001	0.0%	0.0%
0.0005687	1.86576E-05	1.001	0.00001	0.1%	0.0%
0.0017983	5.90004E-05	1.001	0.0001	0.2%	0.2%
0.0056868	0.000186576	1.001	0.001	0.7%	0.5%
0.0179833	0.000590004	1.001	0.01	2.1%	1.6%
0.0568683	0.001865757	1.001	0.1	6.6%	5.0%
0.1271613	0.004171959	1.001	0.5	14.8%	11.1%
0.1608478	0.005277157	1.001	0.8	18.7%	14.0%
0.1798333	0.005900041	1.001	1	20.9%	15.7%
0.2202499	0.007226045	1.001	1.5	25.6%	19.2%
0.237897	0.007805021	1.001	1.75	27.6%	20.7%
0.2543226	0.008343918	1.001	2	29.5%	22.2%
0.3596665	0.011800082	1.001	4	41.8%	31.3%
0.4404997	0.01445209	1.001	6	51.2%	38.4%
0.5086453	0.016687837	1.001	8	59.1%	44.3%
0.5686827	0.018657569	1.001	10	66.1%	49.5%

Vs cm/sec	Vs ft/sec	Ss	d cm	% Removal (Design flow)	% Removal (Peak flow)
0.0005687	1.86576E-05	1.01	0.000001	0.1%	0.0%
0.0017983	5.90004E-05	1.01	0.00001	0.2%	0.2%
0.0056868	0.000186576	1.01	0.0001	0.7%	0.5%
0.0179833	0.000590004	1.01	0.001	2.1%	1.6%
0.0568683	0.001865757	1.01	0.01	6.6%	5.0%
0.1798333	0.005900041	1.01	0.1	20.9%	15.7%
0.4021194	0.013192893	1.01	0.5	46.7%	35.0%
0.5086453	0.016687837	1.01	0.8	59.1%	44.3%
0.5686827	0.018657569	1.01	1	66.1%	49.5%
0.6964912	0.022850761	1.01	1.5	80.9%	60.7%
0.7522965	0.024681643	1.01	1.75	87.4%	65.5%
0.8042388	0.026385786	1.01	2	93.4%	70.1%
1.1373654	0.037315137	1.01	4	100%	99.1%
1.3929824	0.045701523	1.01	6	100%	100%
1.6084775	0.052771573	1.01	8	100%	100%
1.7983326	0.059000412	1.01	10	100%	100%

Vs cm/sec	Vs ft/sec	Ss	d cm	% Removal (Design flow)	% Removal (Peak flow)
0.0017983	5.90004E-05	1.1	1E-06	0.2%	0.2%
0.0056868	0.000186576	1.1	0.00001	0.7%	0.5%
0.0179833	0.000590004	1.1	0.0001	2.1%	1.6%
0.0568683	0.001865757	1.1	0.001	6.6%	5.0%
0.1798333	0.005900041	1.1	0.01	20.9%	15.7%
0.5686827	0.018657569	1.1	0.1	66.1%	49.5%
1.2716131	0.041719591	1.1	0.5	100%	100%
1.6084775	0.052771573	1.1	0.8	100%	100%
1.7983326	0.059000412	1.1	1	100%	100%
2.2024986	0.072260452	1.1	1.5	100%	100%
2.3789704	0.078050209	1.1	1.75	100%	100%
2.5432263	0.083439183	1.1	2	100%	100%
3.5966651	0.118000824	1.1	4	100%	100%
4.4049972	0.144520904	1.1	6	100%	100%
5.0864526	0.166878366	1.1	8	100%	100%
5.6868269	0.186575685	1.1	10	100%	100%

Average Wet Particle Specific Gravity

Vs cm/sec	Vs ft/sec	Ss	d cm	% Removal (Design flow)	% Removal (Peak flow)
0.0040212	0.000131929	**1.5**	0.000001	0.5%	0.4%
0.0127161	0.000417196	**1.5**	0.00001	1.5%	1.1%
0.0402119	0.001319289	**1.5**	0.0001	4.7%	3.5%
0.1271613	0.004171959	**1.5**	0.001	14.8%	11.1%
0.4021194	0.013192893	**1.5**	0.01	46.7%	35.0%
1.2716131	0.041719591	**1.5**	0.1	100%	100%
2.8434134	0.093287843	**1.5**	0.5	100%	100%
3.5966651	0.118000824	**1.5**	0.8	100%	100%
3.8148394	0.125158774	**1.5**	0.9	100%	100%
4.0211939	0.131928932	**1.5**	1	100%	100%
4.9249365	0.161579283	**1.5**	1.5	100%	100%
5.3195395	0.174525573	**1.5**	1.75	100%	100%
5.6868269	0.186575685	**1.5**	2	100%	100%
8.0423877	0.263857864	**1.5**	4	100%	100%
9.8498731	0.323158566	**1.5**	6	100%	100%
11.373654	0.37315137	**1.5**	8	100%	100%
12.716131	0.417195915	**1.5**	10	100%	100%

SAND Specific Gravity

Vs cm/sec	Vs ft/sec	Ss	d cm	% Removal (Design flow)	% Removal (Peak flow)
0.005243	0.000172014	**1.85**	0.000001	0.6%	0.5%
0.0165798	0.000543957	**1.85**	0.00001	1.9%	1.4%
0.05243	0.001720143	**1.85**	0.0001	6.1%	4.6%
0.1657981	0.005439569	**1.85**	0.001	19.3%	14.4%
0.5242995	0.017201428	**1.85**	0.01	60.9%	45.7%
1.6579807	0.054395692	**1.85**	0.1	100%	100%
3.7073575	0.121632466	**1.85**	0.5	100%	100%
4.6894776	0.153854251	**1.85**	0.8	100%	100%
4.9739421	0.163187077	**1.85**	0.9	100%	100%
5.2429953	0.172014282	**1.85**	1	100%	100%
6.4213316	0.21067361	**1.85**	1.5	100%	100%
6.9358309	0.227553507	**1.85**	1.75	100%	100%
7.4147151	0.243264931	**1.85**	2	100%	100%
10.485991	0.344028565	**1.85**	4	100%	100%
12.842663	0.42134722	**1.85**	6	100%	100%
14.82943	0.486529862	**1.85**	8	100%	100%
16.579807	0.543956922	**1.85**	10	100%	100%

Vs cm/sec	Vs ft/sec	Ss	d cm	% Removal (Design flow)	% Removal (Peak flow)
0.0060984	0.00020008	2.15	1E-06	0.7%	0.5%
0.019285	0.000632709	2.15	0.00001	2.2%	1.7%
0.0609844	0.002000801	2.15	0.0001	7.1%	5.3%
0.1928497	0.006327089	2.15	0.001	22.4%	16.8%
0.6098442	0.020008013	2.15	0.01	70.8%	53.1%
1.9284968	0.063270893	2.15	0.1	100%	100%
4.31225	0.141478018	2.15	0.5	100%	100%
5.4546127	0.17895711	2.15	0.8	100%	100%
5.7854905	0.18981268	2.15	0.9	100%	100%
6.0984424	0.200080132	2.15	1	100%	100%
7.4690361	0.245047116	2.15	1.5	100%	100%
8.067481	0.264681136	2.15	1.75	100%	100%
8.6245	0.282956036	2.15	2	100%	100%
12.196885	0.400160264	2.15	4	100%	100%
14.938072	0.490094231	2.15	6	100%	100%
17.249	0.565912073	2.15	8	100%	100%
19.284968	0.632708932	2.15	10	100%	100%

Notes:

% Removal presented above is based on the standard tank dimensions listed below (assumes settling zone length of 14.5 ft).

Where settling velocity is greater than the overflow rate, removal is assumed 100%. Where settling velocity is below overflow rate, removal is assumed to equal settling velocity divided by the overflow rate.

TABLE E-1
LONG-TERM STORMWATER TREATMENT
NORTH BOEING FIELD – SEATTLE, WASHINGTON

For Weir Tank (T-301)

Assume Typical Velocity in Tank through weir opening = (1500 gpm) * (1 ft^3/7.48 gal) / (8.16 ft^2) 24.58 ft / min 0.41 ft / sec

Weir opening is 8.16 ft wide, assume 1ft tall (2 feet above bottom, but 1 ft of solids)

Typical WW sedimentation tank horizontal velocity is 0.15 to 0.90 m/min = 0.492 ft / min to 2.952 ft / min **(Max 0.0492 ft / sec)**

Our design velocity is an order of magnitude higher, but appropriate for settling large particles

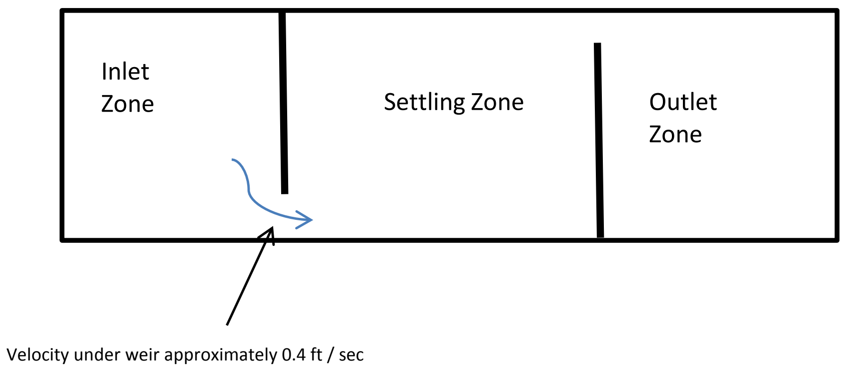
However, the large velocity through the under weir may scour-out, or re-suspend particles, therefore settling is only assumed significant in the Settling zone (PAST the first under weir). Inlet zone only assumed to provide limited sedimentation, some entrapment of floating oil, and energy dissipation.

Overflow Rate = V_0 = Q/A = ft^3 /s/ft^2 (In Settling Zone)

A=Area = WxL = Width (fixed at 8.16 ft) x length (variable below)

Q = 1500 (design flow); 2,000 gpm (max flow)

Design assumption: - *If settling velocity is greater than overflow rate, particle will settle out in the tank.*



Overflow rates as a function of settling zone length and flow rate

V_0 ft / sec	Q gpm	A ft^2	L ft	
0.040959	1500	82	10	
0.034132	1500	98	12	
0.031507	1500	106	13	
0.028248	**1500**	**118**	**14.5**	**Standard tank dimensions**
0.025599	1500	131	16	
0.022755	1500	147	18	
0.054612	2000	82	10	
0.04551	2000	98	12	
0.037663	**2000**	**118**	**14.5**	**Standard tank dimensions**
0.034132	2000	131	16	
0.03034	2000	147	18	

Check:

Volume of settling zone: 5.5'x14.5'x8.16' = 650.76 ft3 4868 gallons

Peak flow scenario 2,000 gpm

Settling zone residence time 2.43 min 146.0 seconds

Particle 1

Particle enters settling zone at 0.41 ft / sec.

Particle has diameter 0.01 cm and specific gravity 1.5; setting velocity = 0.01319 ft / second

If particle enters at height 5 ft, time to fall to tank floor is 379.1 sec

Not likely removed - percent removal is then estimated by ratio of settling velocity to overflow velocity

V_s/V_o = 35%

Particle 2

Particle enters settling zone at 0.41 ft / sec.

Particle has diameter 1.75 cm and specific gravity 1.5; setting velocity = 0.1745 ft / second

If particle enters at height 5 ft, time to fall to tank floor is 28.7 sec

Particle likely reaches the sludge zone before passing through the settling zone (28.7 seconds << 146 seconds)

Notes:

Analysis assumes no interaction between particles, ideal Type 1 sedimentation condtions, no re-suspension of solids once in the sludge zone.

Analysis does not consider sedimentation within the inlet zone, the settling zone (between the two baffles) appears sufficient to reach project goals.

TABLE E-2
LONG-TERM STORMWATER TREATMENT
NORTH BOEING FIELD – SEATTLE, WASHINGTON

Settling Velocities

$$Vs = \sqrt{3.3 \cdot g \cdot (Ss - 1) \cdot d}$$

Vs = Settling Velocity
g = gravity = 9.8 m/s^2
Ss = Specific Gravity of Particles (variable 1.001 to 2.15)
d = Particle diameter (variable 0.4 to 10 cm)

Vs cm/sec	Vs ft/sec	Ss	d cm	% Removal (Design flow)	% Removal (Peak flow)	Vs cm/sec	Vs ft/sec	Ss	d cm	% Removal (Design flow)	% Removal (Peak flow)
0.00018	5.90004E-06	1.001	0.000001	0.3%	0.1%	0.000569	1.87E-05	1.01	0.000001	0.8%	0.3%
0.000569	1.86576E-05	1.001	0.00001	0.8%	0.3%	0.001798	5.9E-05	1.01	0.00001	2.6%	1.0%
0.001798	5.90004E-05	1.001	0.0001	2.6%	1.0%	0.005687	0.000187	1.01	0.0001	8.3%	3.3%
0.005687	0.000186576	1.001	0.001	8.3%	3.3%	0.017983	0.00059	1.01	0.001	26.2%	10.4%
0.017983	0.000590004	1.001	0.01	26.2%	10.4%	0.056868	0.001866	1.01	0.01	82.9%	33.0%
0.056868	0.001865757	1.001	0.1	82.9%	33.0%	0.179833	0.0059	1.01	0.1	100%	100%
0.127161	0.004171959	1.001	0.5	100%	73.8%	0.402119	0.013193	1.01	0.5	100%	100%
0.160848	0.005277157	1.001	0.8	100%	93.4%	0.508645	0.016688	1.01	0.8	100%	100%
0.179833	0.005900041	1.001	1	100%	100%	0.568683	0.018658	1.01	1	100%	100%

Average Wet Particle Specific Gravity

Vs cm/sec	Vs ft/sec	Ss	d cm	% Removal (Design flow)	% Removal (Peak flow)	Vs cm/sec	Vs ft/sec	**Ss**	d cm	% Removal (Design flow)	% Removal (Peak flow)
0.001798	5.90004E-05	1.1	0.000001	2.6%	1.0%	0.004021	0.000132	**1.5**	0.000001	5.9%	2.3%
0.005687	0.000186576	1.1	0.00001	8.3%	3.3%	0.012716	0.000417	**1.5**	0.00001	18.5%	7.4%
0.017983	0.000590004	1.1	0.0001	26.2%	10.4%	0.040212	0.001319	**1.5**	0.0001	58.6%	23.4%
0.056868	0.001865757	1.1	0.001	82.9%	33.0%	0.127161	0.004172	**1.5**	0.001	100%	73.8%
0.179833	0.005900041	1.1	0.01	100%	100%	0.402119	0.013193	**1.5**	0.01	100%	100%
0.568683	0.018657569	1.1	0.1	100%	100%	1.271613	0.04172	**1.5**	0.1	100%	100%
1.271613	0.041719591	1.1	0.5	100%	100%	2.843413	0.093288	**1.5**	0.5	100%	100%
1.608478	0.052771573	1.1	0.8	100%	100%	3.596665	0.118001	**1.5**	0.8	100%	100%
1.798333	0.059000412	1.1	1	100%	100%	4.021194	0.131929	**1.5**	1	100%	100%

Notes:

% Removal presented above is based on the standard tank dimensions listed below (assumes settling zone length of 14.5 ft).

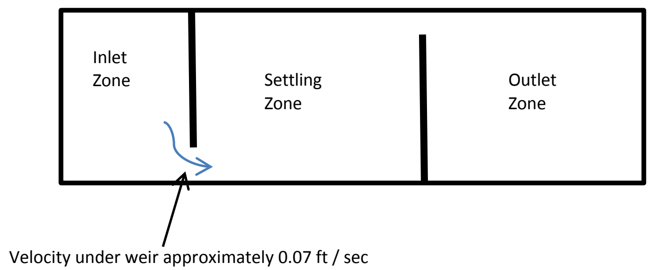
Where settling velocity is greater than the overflow rate, removal is assumed 100%. Where settling velocity is below overflow rate, removal is assumed to equal settling velocity divided by the overflow rate.

TABLE E-2
LONG-TERM STORMWATER TREATMENT
NORTH BOEING FIELD – SEATTLE, WASHINGTON

Assume Typical Velocity in Tank through weir opening = (239 gpm) * (1 ft^3/7.48 gal) / (8.16 ft^2)		3.92 ft / min		0.07 ft / sec	
Weir opening is 8.16 ft wide, assume 1ft tall (2 feet above bottom, but 1 ft of solids)					
Typical WW sedimentation tank horizontal velocity is 0.15 to 0.90 m/min =	0.492 ft / min	to	2.952	ft / min	
		(Max	**0.0492 ft / sec)**		

Our design velocity is somewhat higher, but likely appropriate for settling out the chitosan-attached particles
Because, the higher than typical velocity through the under weir may scour-out sediments, settling is only assumed significant
settling is not considered in the inlet zone. However, bucause of the lower velocities/flow rate, unlike the case with the inlet weir tank,
we assume that significant settling will occur in the outlet zone. Length, area, and therefore overflow rates below include both the settling and outlet
zones shown below.

Overflow Rate = V_0 = Q/A = ft^3 /s/ft^2 (In Settling Zone)
A=Area = WxL = Width (fixed at 8.16 ft) x length (variable below)
Q = 239 (design flow); 600 gpm (max flow)
 - *If settling velocity is greater than overflow rate, particle will settle out in the tank.*



V_0 ft / sec	Q gpm	A ft^2	L ft	
0.003263	239	163	20	
0.002719	239	196	24	
0.00251	239	212	26	
0.00225	**239**	**237**	**29**	**Standard tank dimensions**
0.002175	239	245	30	
0.002039	239	261	32	
0.008192	600	163	20	
0.006826	600	196	24	
0.006301	**600**	**212**	26	
0.00565	**600**	**237**	**29**	**Standard tank dimensions**
0.005461	600	245	30	
0.00512	600	261	32	

Particle size and density for the backwash fluids is unknown.
We anticipate removal of particles between 0.0001 and 0.001 cm, with a typical specific gravity of 1.5 will be
be sufficient to prevent chitosan materials from re-entering the system.

HYDRAULIC ANALYSIS
LONG-TERM STORMWATER TREATMENT
NORTH BOEING FIELD – SEATTLE, WASHINGTON

Hydraulic Analysis Calculations:

The following calculations were completed to evaluate the appropriateness of pump and pipe sizes for conveying treatment system fluids.
The calculations include estimating the total head loss in the piping network due to friction, elevation changes, pipe fittings, and process equipment.

Method Summary:

Create a table of piping network details including diameter of pipe, length of straight runs, and fittings (elbows, etc.)
Look up equivalent length values for fittings
Use Hazen-Williams equation to determine head losses for straight pipe and fittings
Compare total estimated head-loss to the pump performance curve to evaluate ability of the pump to operate effectively

Conclusions:

Pumps sizing and pipe diameters appear appropriate.

Pump **P-301** pumps water from the inlet weir tank into the control station for chitosan injection, then into the storage tanks for settling.
Elements likely to induce head losses for this system are summarized in Table D-3
The sum of these losses, presented in equivalent length, were used in the Hazen-Williams Equation to calculate head loss.
The head loss is estimated to be approximately 25 feet, which is within the operational limits shown in the pump curve for pump model 19BF3R5LO and can accommodate additional changes or fittings necessary during installation.
Net positive suction head (NPSH) is adequate to prevent cavitation.

Pump **P-310A** pumps water from settling tanks, through the control station for chitosan injection, through the sand filters, through the control station for measurement, and either discharged or recirculated based on the water quality. Calculations assume recirculation which requires additional pressure head to enter the 12-inch pipe flowing toward the setting tanks.
Elements likely to induce head losses for this system are summarized in Table D-4
The sum of these losses, presented in equivalent length, were used in the Hazen-Williams Equation to calculate head loss.
The head loss is estimated to be approximately 70 feet, which is within the operational limits of the pump curve for pump model 14A12N5F0. A significant portion of this head is developed by the sand filters - the calculations are based on a pressure across the sand filter bed of 34.6 ft of water (mfg's recommended setpoint for backflush).

Fluid velocities through the pipes range from approximately 5.5 to 10.5 feet per second. At the lower end, this velocity should limit sedimentation within the pipes. The estimated upper limit should appears reasonable to prevent exsessive wear on the system. Velocity is somewhat higher (~12.2 feet per second) inside the control station for the 8" pretreatement pipe run. This velocity was approved by the equipment vendor as appropriate for the control station system components.

TABLE E-3
LONG-TERM STORMWATER TREATMENT
NORTH BOEING FIELD - SEATTLE, WASHINGTON

P-301

Fitting / Pipe	Equiv. Length	El	El	Diameter	Notes
	ft	ft	ft (diff)	inches	
90	18	1	0	10	Pump discharges up
Pipe	1	1	0	10	
90	18	1	0	10	
Pipe	1	1	0	10	On Ground Surface
90	18	0	-1	10	
Check Valve	42	0	-1	10	
Pipe	32	0	0	10	
90	18	0	0	10	
Pipe	5	0	0	10	Rise to Control Station Entrance
90	18	5	5	10	Enter Control Station
Reducer	4	5	0	10	10 to 8 inch reducer
Sum	**175**		**3**		
Pipe	32	5	0	8	In Ctrl Stn.
Misc	65	5	0	8	Monitoring / static mixers, etc.
90	15	5	0	8	Turn to exit control Station
Pipe	2	5	0	8	Exit Control Station
Expander	12	5	0	8	8 to 12 inch expansion (2 steps)
Sum	**126**		0		
90	22	5	0	12	
Pipe	2	5	0	12	
90	22	0	-5	12	
Through - Tee	14	0	0	12	
Pipe	28	0	0	12	
90	22	0	0	12	
Pipe	14	0	0	12	Run to Storage Tank Area
90	22	0	0	12	
Pipe	50	0	0	12	Along length of storage tank
90	22	0	0	12	
Pipe	28	0	0	12	Assume entrance to furthest Tank Port
90	22	0	0	12	
Pipe	5	0	0	12	
90	22	7.5	7.5	12	Assume inlet to storage tanks at 7.5'
Pipe	4	7.5	0	12	
Valve	10	7.5	0	12	Equivalent Length estimated - valve
Sum	**309**		**2.5**		
P-301 - Suction Side					
Pipe	5	2.4	0	10	Out of tank
90	18	2.4	0	10	90 toward ground
Pipe	2	2.4	0	10	2.4 ft to ground
90	18	0	-2.4	10	90 on the ground
Pipe	13	0	0	10	
90	18	0	0	10	
Pipe	2	0	0	10	
90	18	0	0	10	Toward Pump P-301
Pipe	1	0	0	10	
90	18	0	0	10	Toward Pump P-301
90	18	1	1	10	Up to pump inlet
Pipe	2	1	0	10	to pump
SUM	**133**		**-1.4**		

FRICTION LOSS CALCULATOR FOR WATER IN FULL PIPE FLOW
HAZEN-WILLIAMS EQUATION
LONG-TERM STORMWATER TREATMENT
NORTH BOEING FIELD – SEATTLE, WASHINGTON

Hazen-Williams Equation:
$V = k*C*R_h^{0.63}S^{0.54}$ where $S=h_f/L$; $Q=V*A$; $R_h=D/4$
and k=1.381 for English units (ft and seconds)
or k=0.85 for SI units (m and seconds)
Rearanged to solve for head loss in English units:

$h_f = 10.4[Q^{1.85}/(C^{1.85}*D^{4.87})]*L$

where h_f = friction loss in feet of head, Q = flow rate in gallons per minute,
C = Hazen-Williams coefficient for pipe roughness, D = pipe inner diameter in inches,
and L = total equivalent piping length in feet.

10" Pipe

Q =	**1739**	(gallons per minute)	
D =	**9.56**	(inches)	
C =	**140**		
L =	**175**	(ft) length, see Table D-3	
Corresponding pressure drop:			
hf =	**3.27**	(ft)	
	3	(ft)	Additional head loss (elevation change during piping run)
Subtotal 10"	**6.27**	(ft)	
=	2.71	(psi)	
velocity =	7.77	(ft/sec)	

8" Pipe

Q =	**1739**	(gallons per minute)	
D =	**7.63**	(inches)	
C =	**140**		
L =	**126**	(ft) length, see Table D-3	
Corresponding pressure drop:			
hf =	**7.09**	(ft)	
=	3.07	(psi)	
velocity =	12.22	(ft/sec)	(High velocity Ok'd by Clear Water)

12" Pipe to the Storage Tanks

Q =	**2000**	(gallons per minute)	
D =	**9.56**	(inches)	
C =	**140**		
L =	**309**	(ft) length, see Table D-3	
The spreadsheet will calculate the cooresponding pressure drop:			
hf =	**7.50**	(ft)	
	2.5	(ft)	Additional head loss (elevation change during piping run)
Subtotal 12"	**10.00**	(ft)	
=	3.24	(psi)	
velocity =	8.94	(ft/sec)	

TOTALS

	6.27		10"
	7.09	(ft)	8" in Control Unit
	10.00	(ft)	12" run to the storage tanks
Total	**23.36**	**(ft)**	

FRICTION LOSS CALCULATOR FOR WATER IN FULL PIPE FLOW
HAZEN-WILLIAMS EQUATION
LONG-TERM STORMWATER TREATMENT
NORTH BOEING FIELD – SEATTLE, WASHINGTON

Suction-Side

Hazen-Williams Equation:

$V = k*C*R_h^{0.63}S^{0.54}$ where $S=h_f/L$; $Q=V*A$; $R_h=D/4$
and k=1.381 for English units (ft and seconds)
or k=0.85 for SI units (m and seconds)

Rearanged to solve for head loss in English units:

$h_f = 10.4[Q^{1.85}/(C^{1.85}*D^{4.87})]*L$

where h_f = friction loss in feet of head, Q = flow rate in gallons per minute,
C = Hazen-Williams coefficient for pipe roughness, D = pipe inner diameter in inches,
and L = total equivalent piping length in feet.

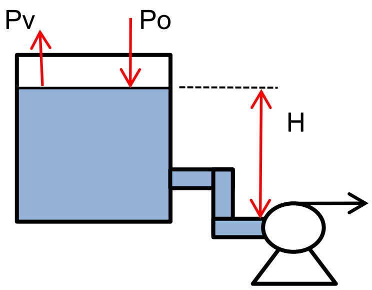
10" Pipe

Q =	**1739**	(gallons per minute)
D =	**9.56**	(inches)
C =	**140**	
L =	**133**	(ft) length, see Table D-3

The spreadsheet will calculate the cooresponding pressure drop:

hf =	**2.49**	(ft)
=	1.08	(psi)
velocity =	7.77	(ft/sec)

$NPSH_a = Po+H-h_f-Pv$



Atmospheric Pressure (Po) =	33.9 ft WC
Total suction side friction losses h_F=	2.486 ft WC
Height of water above pump (H) =	2.4 ft WC
Vapor Pressure; Water at 68F Pv =	.78 ft WC

$NPSH_a$ = 33.03 ft WC

$NPSH_r$ = 7 ft WC (from pump curve)

$NPSH_a$>$NPSH_r$ =>OK

FRICTION LOSS CALCULATOR FOR WATER IN FULL PIPE FLOW
HAZEN-WILLIAMS EQUATION
LONG-TERM STORMWATER TREATMENT
NORTH BOEING FIELD – SEATTLE, WASHINGTON

GOULDS PUMPS
Performance Data

3656 M&L Bronze Fitted
End Suction
MODEL : 19BF3R5L0

Hydraulic Data					Motor Data	3656/3756 M L Group	Qty
Maximum Flow	Flow at Duty Point	Maximum TDH	TDH at Duty Point	$NPSH_R$	Voltage / Phase / Enclosure	Model	
2,797 US g.p.m.	1,500 US g.p.m.	64 ft	60 ft	7 ft	460V 3PH TEFC	19BF3R5L0	1

Submittal Prepared for: ____ Job: ____
Engineer: ____ Contractor: ____
Submittal Prepared by: ____ Company: ____
Submittal Date: 2011-03-23 Approved by: ____ Date: ____

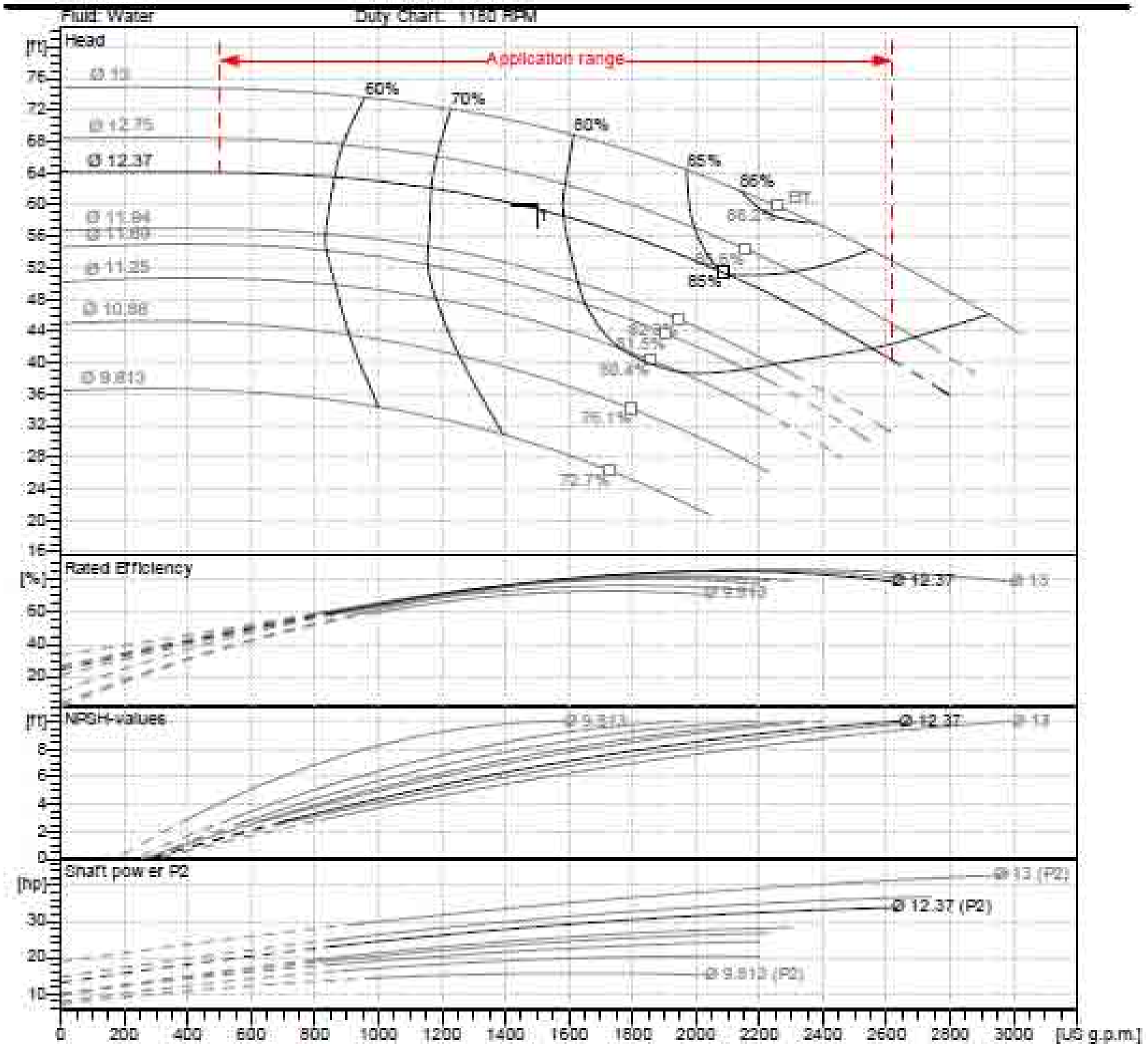


TABLE E-4
LONG-TERM STORMWATER TREATMENT
NORTH BOEING FIELD – SEATTLE, WASHINGTON

P-310A

Fitting / Pipe	Equiv. Length	El	El	Diameter	Notes
	ft	ft	ft (diff)	inches	
90	11	1	0	6	Pump discharges up
Pipe	1	1	0	6	
90	11	0	-1	6	On Ground Surface
Pipe	28	0	0	6	
90	11	0	0	6	
Pipe	4	0	0	6	Rise to Control Station Entrance
90	11	4	4	6	
Pipe	2	4	0	6	Enter Control Station
90	11	4	0	6	Turn to parallel Control Station Wall
Pipe	15	4	0	6	On Rack in Control Station
90	11	4	0	6	Turn to exit control Station
Pipe	2	4	0	6	Exit Control Station
90	11	4	0	6	
Pipe	4	4	0	6	Drop to Ground Surface
90	11	0	-4	6	Turn to match Ground Surface
Pipe	4	0	0	6	
90	11	0	0	6	
Pipe	9	0	0	6	
90	11	0	0	6	
Pipe	17	0	0	6	
90	11	0	0	6	
Pipe	3	0	0	6	Assume Influent port to Sand filters 3' above ground
90	11	0	0	6	
Pipe	5	0	0	6	
Expansion	4	5	5	6	Expand 6 to 10 inches for sand filter inlet
Sand Filters	0	5	0	-	From MFG: 3 to 5 psi drop across clean bed, at 7 to 9 psi, filters will auto-backwash. Pressure drop added as 12 psi (27.7) in Friction loss worksheet
Reducer	4	5	0	6	
Pipe	4	5	0	6	
90	11	0	-5	6	
Pipe	17	0	0	6	
90	11	0	0	6	
Pipe	12	0	0	6	
90	11	0	0	6	
Pipe	1	0	0	6	
90	11	5	5	6	
Pipe	5	5	0	6	
90	11	5	0	6	
Pipe	4	5	0	6	Enter Control Unit
90	11	5	0	6	Turn to parallel Control Station Wall
Pipe	16	5	0	6	On Rack in Control Station
Misc	65	5	0	6	Monitoring / static mixers, etc.
90	11	5	0	8	Exit Control Unit

TABLE E-4
LONG-TERM STORMWATER TREATMENT
NORTH BOEING FIELD – SEATTLE, WASHINGTON

Pipe	5	5	0	8	
90	15	5	0	8	
Pipe	5	5	0	8	
90	15	0	-5	8	
Pipe	1	0	0	8	
45	6	0	0	8	
45	6	0	0	8	
Pipe	4	0	0	8	
90	15	0	0	8	
Branch Tee	37	0	0	8	
Sum	**544**		**-1**		

Assuming water quality fails discharge criteria and must be pumped back to storage tanks

Pipe	28	0	0	12	Run to Storage Tank Area
90	22	0	0	12	
Pipe	12	0	0	12	
90	22	0	0	12	
Pipe	50	0	0	12	Along length of storage tank
90	22	0	0	12	
Pipe	28	0	0	12	Assume entrance to furthest Tank Port
90	22	0	0	12	
Pipe	5	0	0	12	
90	22	7.5	7.5	12	Assume inlet to storage tanks at 7.5'
Pipe	4	7.5	0	12	
Valve	10	7.5	0	12	Equivalent Length estimated - valve
Sum	**247**		**7.5**		

Pipe run represents worst case scenario for the three P-310 pumps; i.e. longest run from pump to control station, and using sand filters furthest from the control station.

P-310A - Suction Side

Fitting / Pipe	Equiv. Length ft	El ft	El ft (diff)	Diameter inches	Notes
Pipe	5	2.5	0	6	
90	11	2.5	0	6	
Pipe	2	2.5	0	6	
90	11	0	-2.5	6	
Pipe	14	0	0	6	
90	11	0	0	6	
Pipe	12	0	0	6	
90	11	0	0	6	

TABLE E-4
LONG-TERM STORMWATER TREATMENT
NORTH BOEING FIELD – SEATTLE, WASHINGTON

Pipe	20	0	0	6
90	11	0	0	6
Pipe	8	0	0	6
90	11	0	0	6
Pipe	4	0	0	6
90	11	0	0	6
Pipe	1	0	0	6
90	11	0	0	6
Pipe	4	0	0	6
Sum	**158**		**-2.5**	

FRICTION LOSS CALCULATOR FOR WATER IN FULL PIPE FLOW
HAZEN-WILLIAMS EQUATION
LONG-TERM STORMWATER TREATMENT
NORTH BOEING FIELD – SEATTLE, WASHINGTON

Hazen-Williams Equation:

$V = k{*}C{*}R_h^{0.63}S^{0.54}$ where $S=h_f/L$; $Q=V{*}A$; $R_h=D/4$
and k=1.381 for English units (ft and seconds)
or k=0.85 for SI units (m and seconds)

Rearanged to solve for head loss in English units:

$h_f = 10.4[Q^{1.85}/(C^{1.85}{*}D^{4.87})]{*}L$

where h_f = friction loss in feet of head, Q = flow rate in gallons per minute,
C = Hazen-Williams coefficient for pipe roughness, D = pipe inner diameter in inches,
and L = total equivalent piping length in feet.

6-inch pipe (includes section of 8-inch pipe for control unit / recirc.)

Q =	**500**	(gallons per minute)
D =	**5.76**	(inches)
C =	**140**	
L =	**544**	(ft) length, see Table D-4

12-inch pipe (assumes recirculation during periods when P-301 is OFF)

Q =	**500**	(gallons per minute)
D =	**11.38**	(inches)
C =	**140**	
L =	**247**	(ft) length, see Table D-4

The spreadsheet will calculate the cooresponding pressure drop:

hf =	**11.94**	(ft)	
	6.5	(ft)	Additional head loss (elevation change during piping run)
	27.68	(ft)	Pressure head across sand filter at backflush setpoint
	23.36	(ft)	Pressure head in Pretreatment line that must be overcome to recirc.
Total	**69.48**	**(ft)**	

velocity =	6.15	(ft/sec)	6-inch
velocity =	3.51	(ft/sec)	8-inch

FRICTION LOSS CALCULATOR FOR WATER IN FULL PIPE FLOW
HAZEN-WILLIAMS EQUATION
LONG-TERM STORMWATER TREATMENT
NORTH BOEING FIELD – SEATTLE, WASHINGTON

Suction-Side

Hazen-Williams Equation:

$V = k*C*R_h^{0.63}S^{0.54}$ where $S=h_f/L$; $Q=V*A$; $R_h=D/4$
and k=1.381 for English units (ft and seconds)
or k=0.85 for SI units (m and seconds)

Rearanged to solve for head loss in English units:

$h_f = 10.4[Q^{1.85}/(C^{1.85}*D^{4.87})]*L$

where h_f = friction loss in feet of head, Q = flow rate in gallons per minute,
C = Hazen-Williams coefficient for pipe roughness, D = pipe inner diameter in inches,
and L = total equivalent piping length in feet.

6" Pipe

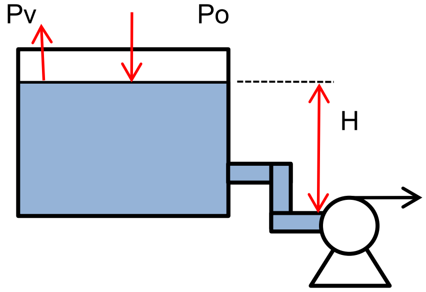
Q =	**500**	(gallons per minute; max flow during backwash, (1500+239)/2=869.5)
D =	**5.76**	(inches)
C =	**140**	
L =	**158**	(ft) length, see Table D-3

Corresponding pressure drop:

hf =	**3.47**	(ft)
velocity =	6.15	(ft/sec)

Total suction side friction losses = 3.467 ft WC

$NPSH_a = Po+H-h_f-Pv$



Atmospheric Pressure (Po) =	33.9 ft WC
Total suction side friction losses h_F=	3.467 ft WC
Height of water above pump (H) =	2.5 ft WC
Vapor Pressure; Water at 68F Pv =	.78 ft WC

$NPSH_a$ = 32.15 ft WC

$NPSH_r$ = 7 ft WC (from pump curve)

$NPSH_a$>$NPSH_r$ =>OK

FRICTION LOSS CALCULATOR FOR WATER IN FULL PIPE FLOW
HAZEN-WILLIAMS EQUATION
LONG-TERM STORMWATER TREATMENT
NORTH BOEING FIELD – SEATTLE, WASHINGTON

GOULDS PUMPS
Performance Data

3656 M&L All Iron
End Suction
MODEL : 14AI2N5F0

Hydraulic Data					Motor Data	3656/3756 M L Group Model	Qty.
Maximum Flow	Flow at Duty Point	Maximum TDH	TDH at Duty Point	$NPSH_R$	Voltage / Phase / Enclosure		
784 US g.p.m.	500 US g.p.m.	136 ft	100 ft	6 ft	460V 3PH TEFC	14AI2N5F0	1

Submittal Prepared for: ______ Job: ______
Engineer: ______ Contractor: ______
Submittal Prepared by: ______ Company: ______
Submittal Date: 2011-03-23 Approved by: ______ Date: ______

Fluid: Water Duty Chart: 1750 RPM

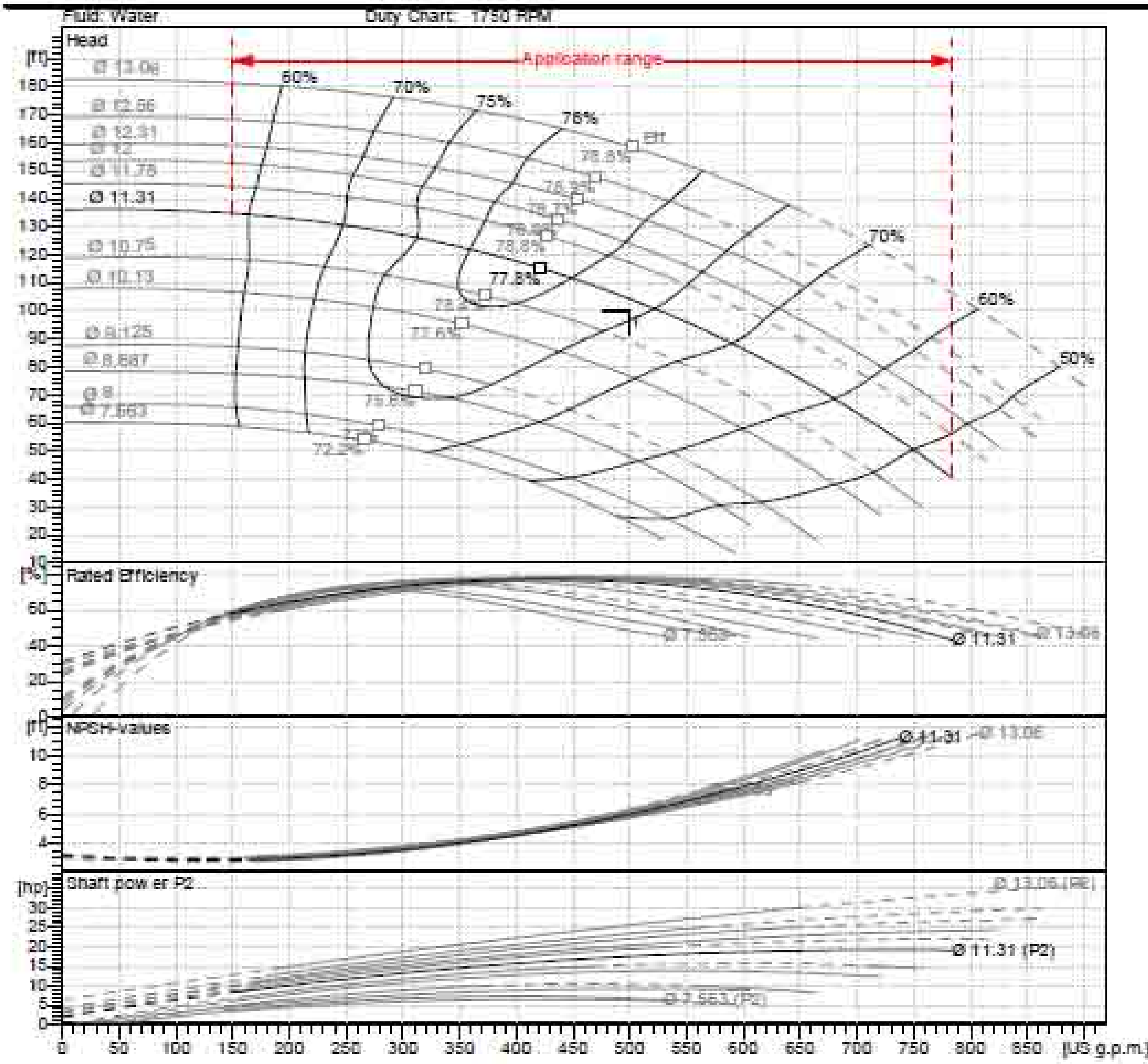


TABLE E-5
HAZEN-WILLIAMS COEFFICIENTS
LONG-TERM STORMWATER TREATMENT
NORTH BOEING FIELD - SEATTLE, WASHINGTON

Material	C
Plastic (PVC, PE)	140-150
Steel, new unlined	140
Copper	130-140
Galvanized iron	120
Cast Iron:	
New, unlined	130
10 yr. old	107-113
20 yr. old	100
30 yr. old	90
Brick Sewer	100
Corrugated Steel Pipe	60

TABLE E-6
PIPE FITTINGS – EQUIVALENT PIPE LENGTHS
LONG-TERM STORMWATER TREATMENT
NORTH BOEING FIELD – SEATTLE, WASHINGTON

Nominal Pipe Size (Inches)	Equivalent Feet of Pipe								
	90^o Elbow	45^o Elbow	Tee, Side Outlet	Insert Coupling	PVC Male-Female Insert Adapters	Globe Valve (fully open)	Angle Valve (fully open)	Gate Valve (fully open)	Check Valve
3/8	0.9	0.5	3.0	----	----	----	----	----	----
1/2	1.6	0.6	4.0	0.5	1.0	----	----	----	----
3/4	2.1	1.1	5.0	0.8	1.5	23	12	0.5	5
1	2.6	1.4	6.0	1.0	2.0	29	15	0.6	7
1-1/4	3.5	1.8	7.0	1.3	2.8	39	20	0.8	9
1-1/2	4.0	2.1	8.0	1.5	3.5	45	23	1.0	11
2	5.5	2.8	12.0	2.0	4.5	58	29	1.2	14
2-1/2	6.2	3.3	15.0	3.0	----	69	35	1.4	15
3	7.7	4.1	16.0	3.0	6.3	85	43	1.8	19
4	10.1	5.4	22.0	4.0	9.0	112	57	2.3	25
6	15.2	8.1	32.0	6.3	14.0	168	84	3.4	40
8	20.0	10.6	38.0	----	----	225	115	4.6	50

TABLE E-7
EQUIVALENT LENGTH OF VALVES AND FITTINGS IN FEET
LONG-TERM STORMWATER TREATMENT
NORTH BOEING FIELD - SEATTLE, WASHINGTON

Nominal Pipe size, in.	Globe Valve or Ball Check Valve	Angle valve	Swing Check Valve	Plug Cock	Gate or Ball Valve	45^o Ell	90^o Ell, Long Radius	90^o Ell, Short Radius	Branch Tee	Through Tee	90^o Miter Elbows			Expander					Reducer				
														Sudden			Std Redu		Sudden			Std Redu	
														Equivalent Length in terms of small diameter									
											2 Miters	3 Miters	4 Miters	d/D=1/4	d/D=1/2	d/D=3/4	d/D=1/2	d/D=3/4	d/D=1/4	d/D=1/2	d/D=3/4	d/D=1/2	d/D=3/4
	L/D =	L/D =	L/D =	L/D =	L/D =	L/D =	L/D =	L/D =	L/D =	L/D =	L/D =	L/D =	L/D =	L/D =	L/D =	L/D =	L/D =	L/D =	L/D =	L/D =	L/D =	L/D =	L/D =
	407	**192**	**99**	**81**	**12**	**12**	**17**	**23**	**58**	**17**	**28**	**21**	**20**	**41**	**23**	**6**	**29**	**6**	**17**	**17**	**6**	**6**	**2**
1 1/2	55.0	26.0	13.0	7.0	1.0	1.0	2.0	3.0	8.0	2.0				5	3	1	4	1	3	2	1	1	
2	70.0	33.0	17.0	14.0	2.0	2.0	3.0	4.0	10.0	3.0				7	4	1	5	1	3	3	1	1	
2 1/2	80.0	40.0	20.0	11.0	2.0	2.0	3.0	5.0	12.0	3.0				8	5	2	6	2	4	3	2	2	
3	100.0	50.0	25.0	17.0	2.0	2.0	4.0	6.0	14.0	4.0				10	6	2	8	2	5	4	2	2	
4	130.0	65.0	32.0	30.0	3.0	3.0	5.0	7.0	19.0	5.0				12	8	3	10	3	6	5	3	3	
6	200.0	100.0	48.0	70.0	4.0	4.0	8.0	11.0	28.0	8.0				18	12	4	14	4	9	7	4	4	1
8	260.0	125.0	64.0	120.0	6.0	6.0	9.0	15.0	37.0	9.0				25	16	5	19	5	12	9	5	5	2
10	330.0	160.0	80.0	170.0	7.0	7.0	12.0	18.0	47.0	12.0				31	20	7	24	7	15	12	6	6	2
12	400.0	190.0	95.0	170.0	9.0	9.0	14.0	22.0	55.0	14.0	28	21	20	37	24	8	28	8	18	14	7	7	2
14	450.0	210.0	105.0	80.0	10.0	10.0	16.0	26.0	62.0	16.0	32	24	22	42	26	9			20	16	8		
16	500.0	240.0	120.0	145.0	11.0	11.0	18.0	29.0	72.0	18.0	38	27	24	47	30	10			24	18	9		
18	550.0	280.0	140.0	160.0	12.0	12.0	20.0	33.0	82.0	20.0	42	30	28	53	35	11			26	20	10		
20	650.0	300.0	155.0	210.0	14.0	14.0	23.0	36.0	90.0	23.0	46	33	32	60	38	13			30	23	11		
22	688.0	335.0	170.0	225.0	15.0	15.0	25.0	40.0	100.0	25.0	52	36	34	65	42	14			32	25	12		
24	750.0	370.0	185.0	254.0	16.0	16.0	27.0	44.0	110.0	27.0	56	39	36	70	46	15			35	27	13		
30				312.0	21.0	21.0	40.0	55.0	140.0	40.0	70	51	44										
36					25.0	25.0	47.0	66.0	170.0	47.0	84	60	52										
42					30.0	30.0	55.0	77.0	200.0	55.0	98	69	64										
48					35.0	35.0	65.0	88.0	220.0	65.0	112	81	72										
54					40.0	40.0	70.0	99.0	250.0	70.0	126	90	80										
60					45.0	45.0	80.0	110.0	260.0	80.0	190	99	92										

NORTH BOEING FIELD-PEL REMEDIATION

PHASE 2 RE-ROUTE STORMWATER LINES

HYDRAULIC CALCULATIONS

URS INDEPENDENT TECHNICAL REVIEW REPORT Quality

Project Name:	**PEL Remediation**	**Project Number:**	**33762889.03000**
Project Location:	**North Boeing Field, Seattle, WA**	**Client Name:**	**Boeing Airplane Co**
PM Name:	**Kris Turschmidt**	**PIC Name:**	**Vivianne Knight**

Identifying Information

(This section is to be completed by the Project Manager.)

Assigned Independent Technical Reviewer: Phil Newton   Reviewer's Comments required by: 5/25/2011

Work Product Originator: John Gillespie

Work Product to be Reviewed: OWS 421 Stormwater Pump Specification, Drawings and Calculations

Review Scope: Provide review of Drawings, Specification and Calcualtions]

Submitted by: ______________________ **May 24, 2011**

Project Manager Signature **Date**

Independent Technical Review – Part 1: Comments

(This section is to be completed by the Reviewer.)

Check box A or B:

A. ☐ Reviewer performed review and has no comments.

or

B. ☒ The Reviewer's comments have been provided on:

☒ Marked directly on Work Product
☐ Comment and Disposition Form (Form 3-5 (MM))
☐ Other Specify: _____

Phil Newton, PE   May 24, 2011

Reviewer Signature **Date**

Independent Technical Review – Part 2: Verification

(This section is to be completed by the Reviewer after verification of comment resolution, if box B is checked off above.)

Check box C or D and then E:

C. ☒ Verification of comment resolution has been performed by Reviewer AND any significant issues have been resolved between Originator and Reviewer.

or

D. ☐ Verification of comment resolution has been performed by Reviewer AND unresolved issues have been submitted to the Project Manager, Principal-in-Charge or designee for resolution.

and

E. ☐ Verification of correct incorporation of resolved comments into final Work Product is complete.

Philip G. Newton   May 26, 2011

Reviewer Signature **Date**

APPROVAL and DISTRIBUTION

(To be signed after box A or E are completed.)

☒ The review is complete. Significant issues not resolved between the Reviewer and the Originator, if any, have been resolved by the Approver.

______________________ 5/27/11

Project Manager, Principal-in-Charge or Designee Signature **Date**

Distribution:

Project Central File – Quality file folder
Other Specify: _____

The stormwater into MH 130A per the stormwater flow revisions has been calculated by URS will be approx. 530 gpm.

Existing Pump Data ⇒ Goulds Model 4NS submersible sewage pump (lea); 10 HP w/ 8" impeller; Pump On Elev = 4.6' & Pump off Elev = 3.3'

The new force main (8" HDPE) from MH 130A to the new LTST facility is approx. 1,520 ft. long. The total head loss (TDH) was calculated to be approx. 28 ft. (see sheet 2).

From the pump curve (see sheet 3), it appears the existing 10 HP pump will pump 530 gpm at a TDH of 28 feet.

The maximum pumping rate @ 28 feet of TDH for the 10 HP pump is approx. 750 gpm. A throttling will be installed on the 8-inch force main, near MH 130A, to control the pumping flow to 530 gpm.

HEADLOSS CALCULATIONS

PROJECT: **Boeing Field North** — **Red** cells are input cells
PIPING SYSTEM: **New Forcemain from MH 130A to the New Treatment Facility**
Job Number:
Date: 4/18/2011
Engineer: **J. Gillespie**

BASIC DATA

Total Headloss = Friction Loss + Minor Losses
Friction Loss = $10.44 x L x Q^{1.85}/C_{HW}^{1.85} x D^{4.8655}$ (Hazen-Williams Equation)
Minor Losses = K x $V^2/2g$
Friction Factor, C_w: **130** (HDPE pipe)
Downstream WS Elev NA

PIPE SECTION

Flow	**530** gpm	0.7632 mgd
Length of Pipe	**1520** ft	
Type of Pipe	**8** in. (HDPE DR 17)	
Inside Diameter	**7.549** in	
Velocity	3.80 fps	

Fittings	No.	K	K_{total}
90° Elbows	**4**	0.3	1.2
45° Elbows	**12**	0.2	2.4
Run of Tee's	**0**	0.6	0
Reducer	**3**	0.5	1.5
Valves			
Plug Valve	**1**	1	1.0
Knife Gate Valve	**3**	0.3	0.9
Check Valve	**1**	1	1.0
Entrance Loss	**1**	0.5	0.5
Exit Loss	**1**	1.0	1.0
Total K			9.5

Total Headloss in Piping Section, ft	**13.57**
Static Headloss from MH 130A to New Weir Tank, ft (see note)	**14.00**
TDH =	**27.57**

Note: Static headloss was calculated based on the following - ground surface elev. at weir tank = 12 feet; elev. of forcemain connection at weir tank = 17 feet; lowest water elevation in MH 130A = 3 feet. Static HL = 17 feet - 3 feet = 14 feet

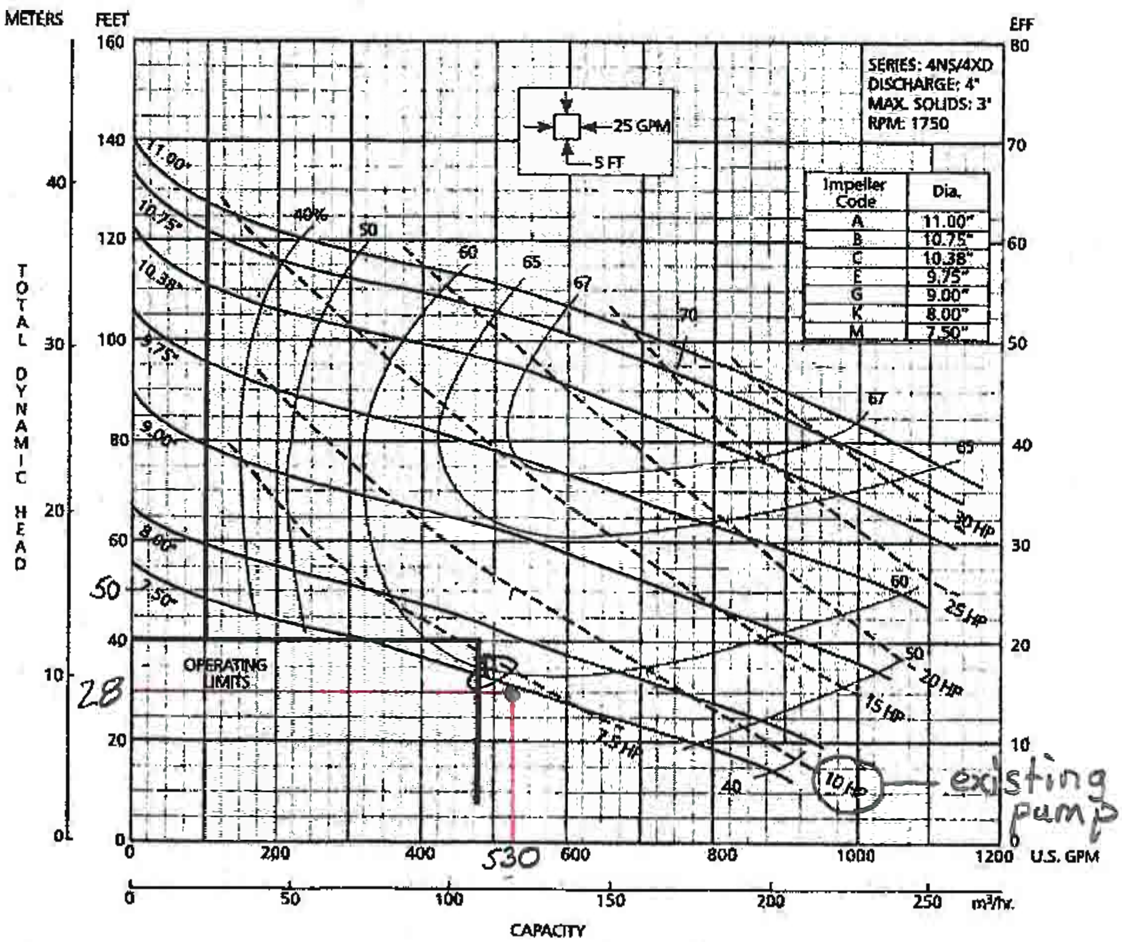
C4NS

ITT

Wastewater

Goulds Pumps

4NS Submersible Sewage Pumps PERFORMANCE CURVE



GOULDS PUMPS

Goulds Pumps is a brand of ITT Corporation.

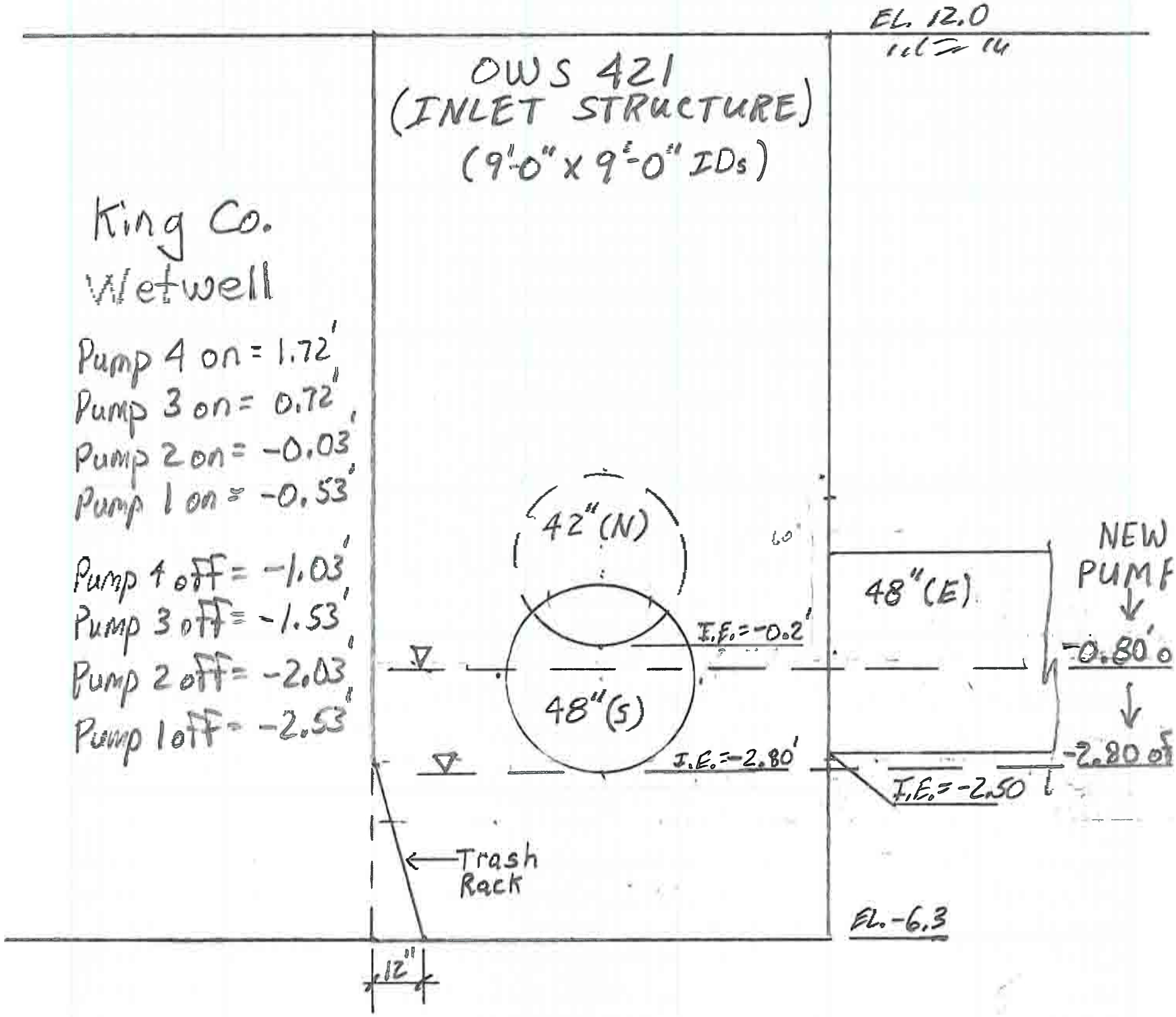
www.goulds.com

Engineered for life

Customer ____________	
Pump Item ____________	
Condition of Service	Imp. Dia. ________
______GPM ______TDH ______ EFF%	
Certified for:	Approval ☐
By________ Date ________	Record ☐

Job Boeing N. Field Project No. 33762889
Description Inlet Structure Pumps Computed by JFG Date 4-19-11
Checked by ___ Date ___
Reference

Wetted area of inlet structure plus King Co. wetwell =
$(9' \times 9') + (32' \times 9') = 369$ sf



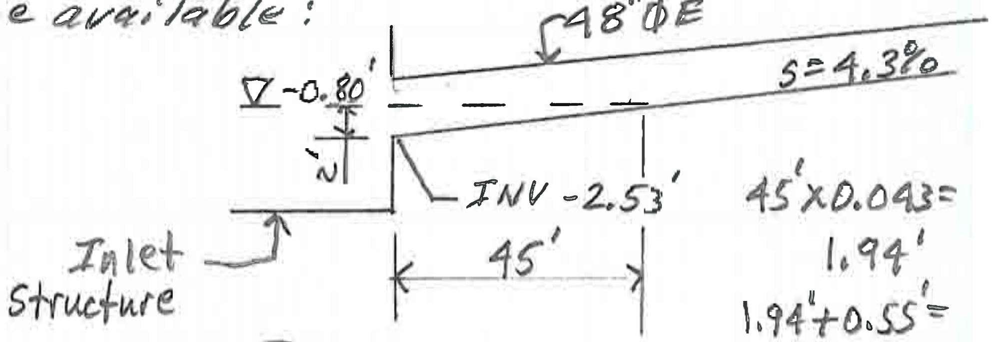
Volume of water stored between pump on (-0.55') and pump off (-2.53'): depth = 2'

Wetted area in inlet structure and KC pump sta. = 369 sf

Wetted area vol. = 369 sf x 2' x 7.48 gal/ft³ = 5,500 gal

Other storage areas are the 2-48"Φ inlet pipes.

The 48"ΦE pipe is 115' long at a slope of 4.3%. The water rises 2' in the pipe at the inlet structure. The storage available:



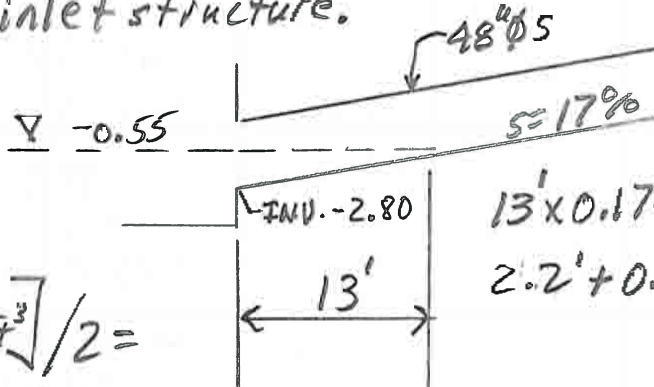
45' x 0.043 = 1.94'

1.94' + 0.55' = 2.49 ≈ 2.53

$$48"\Phi E \text{ pipe storage} = \left[\left[\frac{3.14\times 4'^2}{4}/2\right]\times 45'\times 7.48\ gal/ft^3\right]/2 =$$

1,050 gal

The 48"ΦS pipe is 25' at a slope of 17%. The water rises 2' in the pipe at the inlet structure.



13' x 0.17 = 2.2'

2.2' + 0.55 = 2.7 ≈ 2.80'

$$48"\Phi S \text{ pipe storage} = \left[\left[\frac{3.14\times 4^2}{4}/2\right]\times 13'\times 7.48\ gal/ft^3\right]/2 =$$

305 gal

TOTAL STORAGE = 5500 + 1050 + 300 = $\boxed{6{,}850\ gal}$

URS

Job Boeing N. Field | Project No. 33762889 | Page 3 of 7 | Sheet ___ of ___

Description Inlet Structure | Computed by JFG | Date 4-21-11

Pumps | Checked by ______ | Date ______

Reference

From revised stormwater flow calcs by URS due to existing pipe changes, it was calculated that 530 gpm (max) would flow into MH 130A. Since the maximum treatment rate for the new treatment system is 1,500 gpm, the pumping rate for the OWS 421 pump will vary between 970 gpm and up to 1500 gpm. A VFD will be used to control the pump speed.

See Pages 4 & 5 for TDH calcs at pump rates 970 gpm and 1500 gpm.

See Pages 6 & 7 for pump and VFD curves. At a TDH of 22 feet (from Page 4), the max. pump rate at a pump speed of 1150 rpm is approx. 1,475 gpm. The max. flow from OWS 421 to the treatment facility will be 1,475 gpm±.

Approx. pump cycle @ 1475 gpm = 6850 gal / 1475 gpm = 4.6 min.

Approx. pump cycle @ 970 gpm = 6850 gal / 970 gpm = 7 min.

HEADLOSS CALCULATIONS

PROJECT: **Boeing Field North** — **Red** cells are input cells
PIPING SYSTEM: **New Forcemain from OWS 421 (Inlet Structure) Pump to Weir Tank**
Job Number:
Date: 4/19/2011
Engineer: J. Gillespie

BASIC DATA

Total Headloss = Friction Loss + Minor Losses + Static Loss
Friction Loss = $10.44 x L x Q^{1.85}/C_{HW}^{1.85} x D^{4.8655}$ (Hazen-Williams Equation)
Minor Losses = K x $V^2/2g$
Friction Factor, C_w: **130** (ductile iron pipe)
Downstream WS Elev NA

PIPE SECTION

Flow **1500** gpm (max) 2.16 mgd
Length of Pipe **170** ft
Diameter **12** in
Velocity 4.26 fps

Fittings	No.	K	K_{total}
90° Elbows	**6**	0.3	1.8
45° Elbows	**0**	0.2	0
Run of Tee's	**0**	0.6	0
Reducer	**3**	0.5	1.5
Valves			
Plug Valve	**0**	1.0	0.0
Knife Gate Valve	**2**	0.3	0.6
Check Valve	**1**	1	1.0
Entrance Loss	**1**	0.5	0.5
Exit Loss	**1**	1.0	1.0
Total K			6.4

Total Headloss in Piping Section, ft	**2.72**
Static Headloss from Inlet Structure to New Weir Tank, ft (see note)	**19.50**
TDH =	**22.22**

Note: Static headloss was calculated based on the following - ground surface elev. at weir tank = 12 feet; elev. of forcemain connection at weir tank = 17 feet; lowest water elevation in inlet struture= -2.5 feet.
Static HL = 17 feet + 2.5 feet = 19.5 feet

HEADLOSS CALCULATIONS

PROJECT:	**Boeing Field North**	**Red** cells are input cells
PIPING SYSTEM:	**New Forcemain from OWS 421 (Inlet Structure) Pump to Weir Tank**	
Job Number:		
Date:	4/19/2011	
Engineer:	**J. Gillespie**	

BASIC DATA

Total Headloss = Friction Loss + Minor Losses + Static Loss

Friction Loss = $10.44 x L x Q^{1.85}/C_{HW}^{1.85} x D^{4.8655}$ (Hazen-Williams Equation)

Minor Losses = K x $V^2/2g$

Friction Factor, C_w: **130** (ductile iron pipe)

Downstream WS Elev NA

PIPE SECTION

Flow	**970** gpm (min)	1.3968 mgd
Length of Pipe	**170** ft	
Diameter	**12** in	
Velocity	2.75 fps	

Fittings	No.	K	K_{total}
90° Elbows	**6**	0.3	1.8
45° Elbows	**0**	0.2	0
Run of Tee's	**0**	0.6	0
Reducer	**3**	0.5	1.5
Valves			
Plug Valve	**0**	1.0	0.0
Knife Gate Valve	**2**	0.3	0.6
Check Valve	**1**	1	1.0
Entrance Loss	**1**	0.5	0.5
Exit Loss	**1**	1.0	1.0
Total K			6.4

Total Headloss in Piping Section, ft	**1.16**
Static Headloss from Inlet Structure to New Weir Tank, ft (see note)	**19.50**
TDH =	**20.66**

Note: Static headloss was calculated based on the following - ground surface elev. at weir tank = 12 feet; elev. of forcemain connection at weir tank = 17 feet; lowest water elevation in inlet struture= -2.5 feet. Static HL = 17 feet + 2.5 feet = 19.5 feet

Pump Data Sheet - HYDROMATIC

HYDROMATIC

Company: PumpTech Inc.
Name: Boeing North Storm Water
Date: 4/21/2011

1,500 GPM at 23 ft

Pump:

Size: S6A/S6AX
Type: NCLOG-6
Synch speed: 1200 rpm
Speed: 1150 rpm
Dia: 10.4375 in
Curve: S6A1150
Impeller:
Specific Speeds:
Ns: —
Nss: —
Dimensions:
Suction: —
Discharge: 6 in

Pump Limits:

Temperature: 140 °F
Pressure: 125 psi g
Sphere size: 3.75 in
Power: —
Eye area: —

Search Criteria:

Flow: 1460 US gpm
Head: 23 ft

Fluid:

Water
Density: 62.37 lb/ft³
Viscosity: 1.105 cP
NPSHa: —
Temperature: 60 °F
Vapor pressure: 0.2563 psi a
Atm pressure: 14.7 psi a

Motor:

Consult HYDROMATIC to select a motor for this pump.

— Data Point —

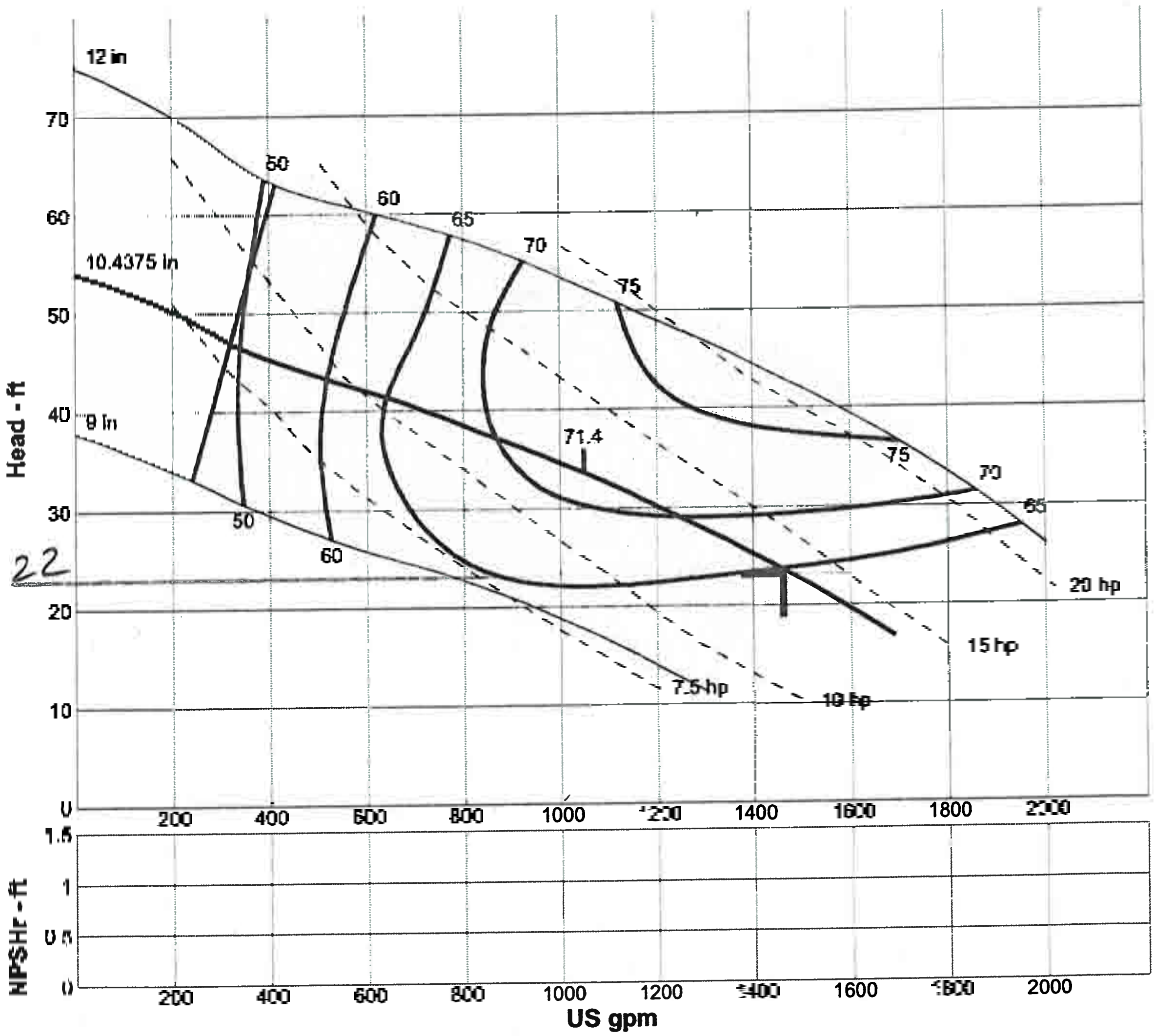
Flow:	1460 US gpm
Head:	23.6 ft
Eff:	65%
Power:	13.4 hp
NPSHr:	—

— Design Curve —

Shutoff head:	54.1 ft
Shutoff dP:	23.4 psi
Min flow:	304 US gpm
BEP:	71% @ 1047 US gpm
NOL power:	14.1 hp @ 1688 US gpm

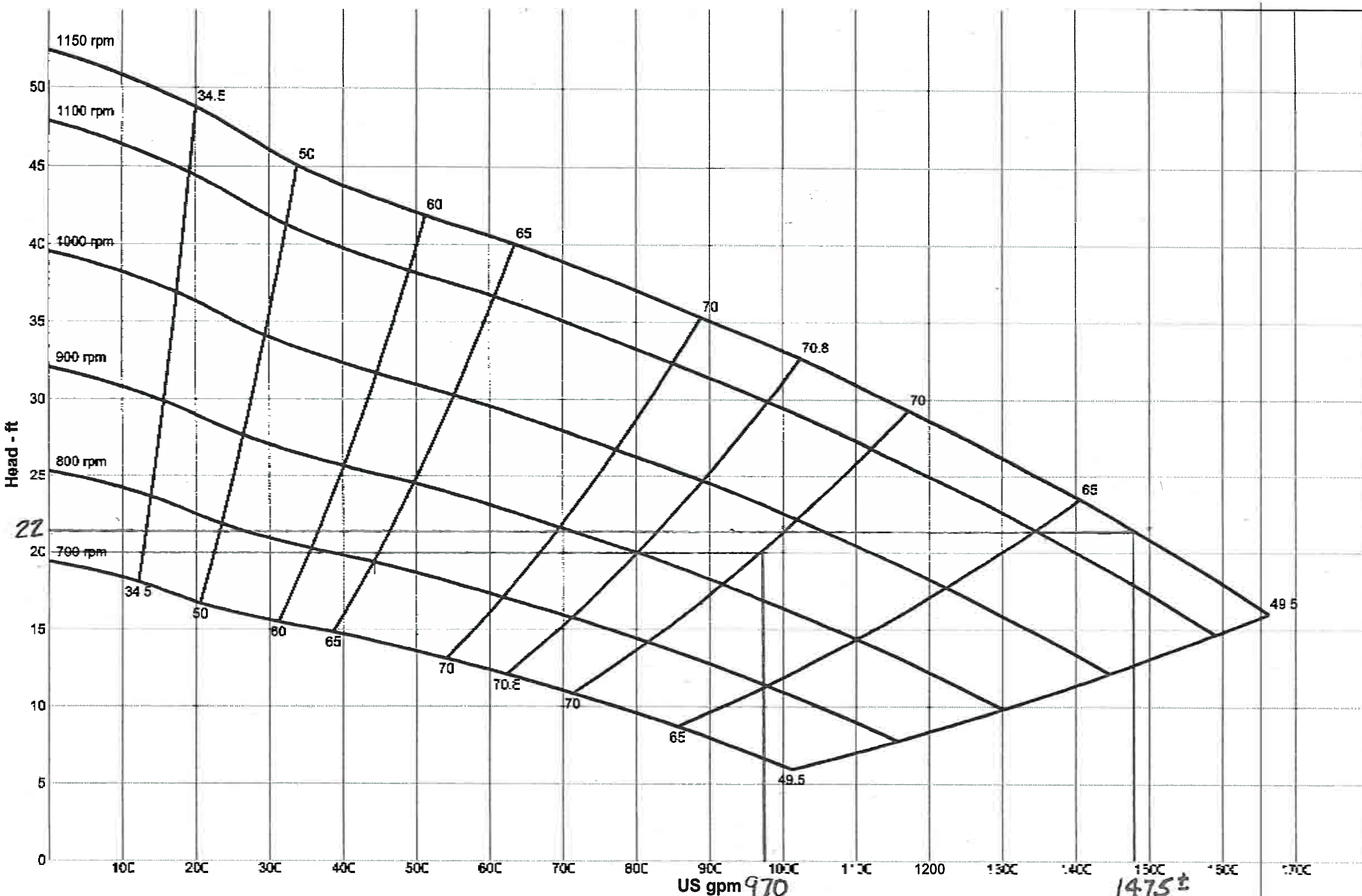
— Max Curve —

Max power: 21.4 hp @ 2000 US gpm



Performance Evaluation:

Flow US gpm	Speed rpm	Head ft	Efficiency %	Power hp	NPSHr ft
1752	1150	—	—	—	—
1460	1150	23.6	65	13.4	—
1168	1150	30.8	71	12.8	—
876	1150	37	70	11.7	—
584	1150	42.3	63	9.92	—



Company: PumpTech Inc. - North Boeing
Name: Multi speed for S6AX
4/21/2011

HYDROMATIC
Catalog: Non-Clog Pumps 60Hz, Vers Nov 2009
NCLOG-6 - 1200

Size: S6A/S6AX
Speed: 700 - 1150 rpm
Dia: 10.3125 in
Curve: S6A1150

HYDROMATIC

Vault is to be sized to accomodate 1,000 gpm max. flow and be able to accomodate pumps in the future. The current plan is for stormwater to gravity flow through the vault.

Vault Size: 1000 gpm pump should cycle every 5 to 6 minutes. For a 5 minute cycle storage should accomodate 5,000 gallons or 669 cf.

Try a 12'x25' vault with a 2.5' on/off pump distance. Pump storage = 12'x25'x2.5'x7.48 gal/ft³ = 5,610 gal.

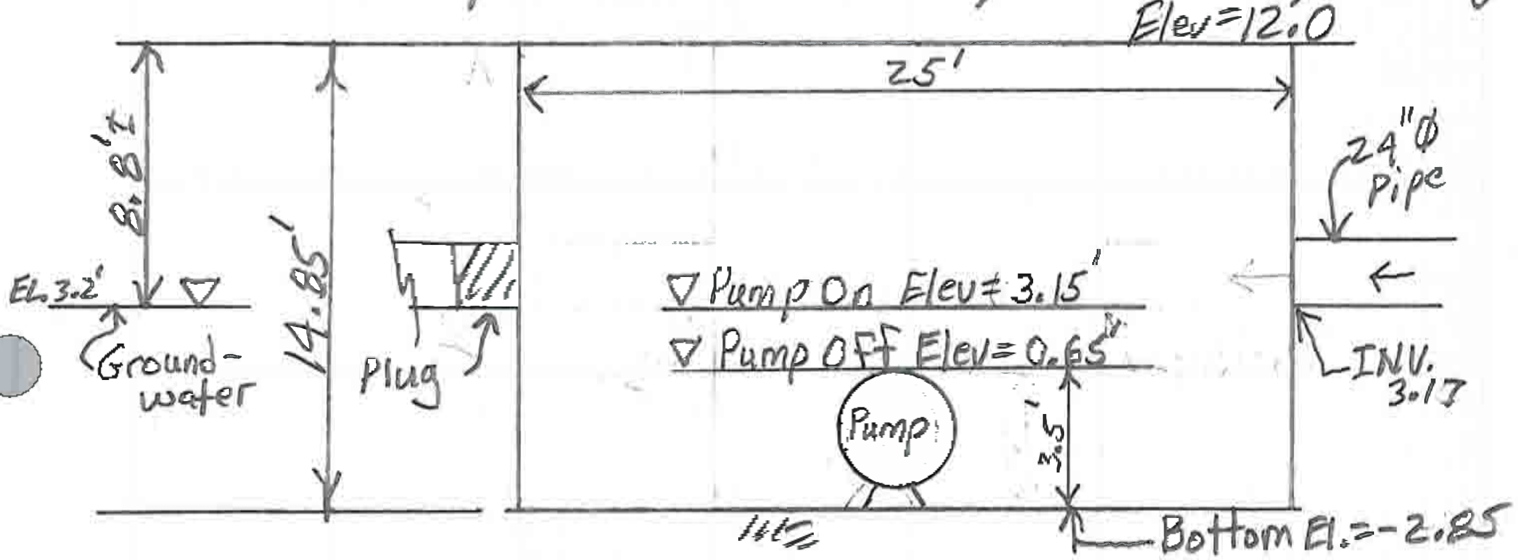
Pump cycle = 5610 gal / 1,000 gal/min = 5.6 min

Assume depth of water to cover pump = 42" or 3.5'

Depth from bottom of wetwell to pump on elev. = 3.5' + 2.5' = 6'

From Cris Castro (URS) IE of 24" gravity pipe at point of vault center = 3.16'. Slope on pipe = 0.1%

Vault Layout for Future Pump w/o Surcharge Storage



URS

Job: Boeing N. Field | Project No. 33762889 | Page 2 of 2
Description: Size of Vault for Stormwater | Computed by JFG | Sheet ___ of ___ | Date 4-22-11
Checked by ______ | Date ______
Reference

Check for buoyance

Uplift force = $27' \times 14' \times 7' \times 62.4\ lbs/ft^3 = 166{,}000\ lbs$ (L, W, D)

Tank wt. ⇒ wall wt. = $(27' + 27' + 12' + 12') \times 14.85' \times 1'$ (wall tk.) $\times 150\ lbs/ft^3 = 173{,}700\ lbs$

bottom wt. = $27' \times 12' \times 1' \times 150\ lbs/ft^3 = 48{,}600\ lbs$

Tank wt. = $173{,}700\ lbs + 48{,}600\ lbs = 222{,}300\ lbs > 166{,}000\ lbs$ ok!

Check Vault size if upsteam 24"Ø pipe is fully surcharged. 24"Ø pipe is basically flat, at 0.01%. Assume 90% of pipe length is fully surcharged. Pipe length = 122' ⇒ 90% × 122' = 110'

Water surcharge volume in 24"Ø pipe = $\frac{3.14(2^2)}{4} \times 110' \times 7.48 =$ 2,580 gals.

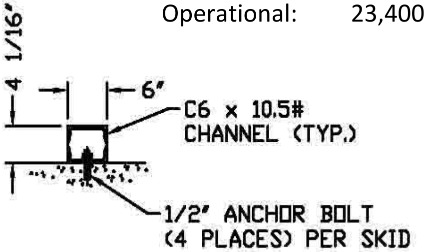
For the 5 min. pump cyle of 5,000 gal, an additional 2500 gal. of storage is need. From Page 1 diagram, pump on elev. = 5.17' for pipe surcharge. Use same pump off elev = 0.65'. Water depth = 5.17' − 0.65' = 4.52'. For 2500 gal., a volume of 334 cf (2500 gal / 7.48 gal/cf) is needed. Area needed = 334 cf / 4.52' = 74 sf.

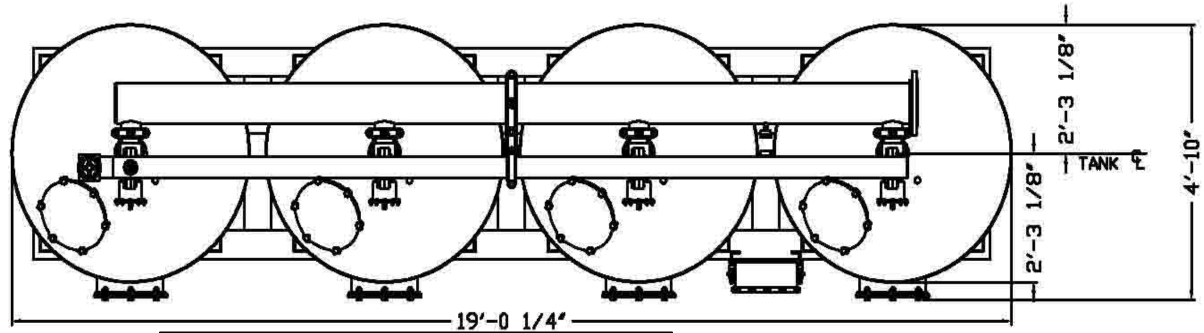
Vault size = $\boxed{9' \times 9'}$

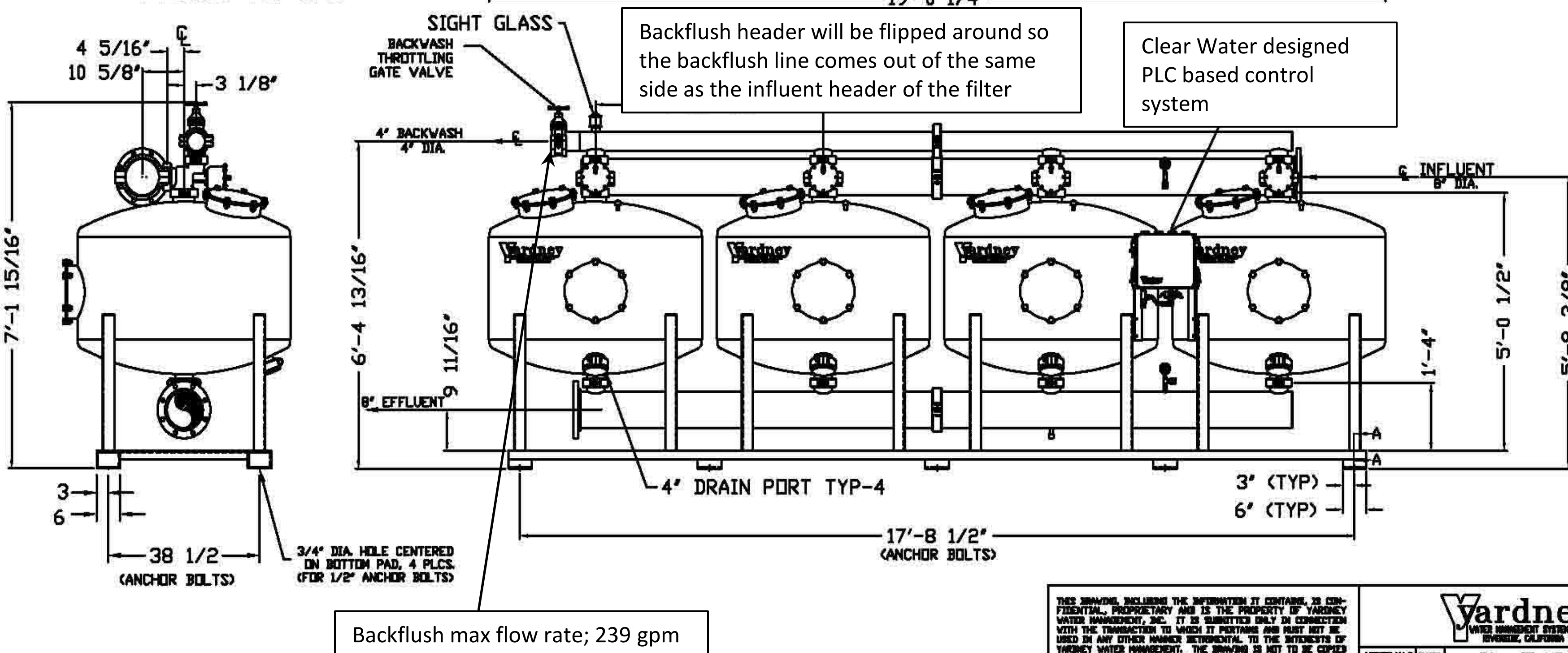
IL 5424-4A

NOTES:

1. FLOW RATE DESIGN: Max: 700gpm Nominal: 500gpm
2. MAXIMUM WORKING PRESSURE: 60 PSI
3. ELECTRICAL REQUIREMENTS:
   CONTROLLER 120V;
   SOLENOIDS 24VAC; FACTORY WIRED
4. AIR SUPPLY REQUIRED: 2 CFM @ 70 PSIG (MIN.).
5. MEDIA REQUIREMENT PER TANK: ¾" washed gravel; 700lbs/pod = 2,800lbs
   Garnet ; 700lbs/pod = 2,800lbs
   20/30 silica sand; 1600lbs/pod = 6400lbs
6. WEIGHTS: (APPROX.)
   Equipment: 4,800 lbs
   Media: 12,000 lbs
   Operational: 23,400 lbs







Yardney WATER MANAGEMENT SYSTEMS RIVERSIDE, CALIFORNIA

SYM	REVISIONS	BY	DATE	APP
A	ADDED 4" DRAIN PORT; CHG PIPE FROM 6" TO 8"	DTC	11-99	

APPROVALS | DATE — DTC

IL 5424-4A FILTER SYSTEM

SCALE: NONE | SIZE: – | DRAWING NO. 9500542400 | REV A

SYSTEM\IL | SHEET 1 OF 1

APPENDIX F

Construction Specifications

100% Technical Specifications

NBF-PEL Remediation
Phase 2 Re-route Stormwater Lines

Submitted to
United States Environmental Protection Agency

June 24, 2011

URS

DIVISION 1 – GENERAL REQUIREMENTS

DIVISION 2 – SITE WORK

DIVISION 3 – CONCRETE

DIVISION 16 – ELECTRICAL

SECTION 01090

REFERENCE STANDARDS

1. GENERAL

1.1 DESCRIPTION OF WORK

A. This Section summarizes the names of organizations identified by abbreviation elsewhere in the Contract Documents.

B. This Section includes:
   1. Quality assurance.
   2. Applicable editions of references.
   3. Schedule of references.

1.2 QUALITY ASSURANCE

A. For products or workmanship specified by Association, Trade, or Federal Standards, comply with requirements of the standard, except when more rigid requirements are specified or are required by applicable codes.

B. Should specified Reference Standards conflict with Contract Documents, request clarification from Engineer before proceeding.

1.3 APPLICABLE EDITIONS OF REFERENCES

A. Wherever specifications, codes, or standards are referred to in these specifications, without designation of year, the reference is to the current or revised specification, code, or standard effective at the time of receiving proposals.

1.4 SCHEDULE OF REFERENCES

A. AABC — Associated Air Balance Council, 1000 Vermont Avenue, N.W., Washington, D.C 20005.

B. ABMA — American Boiler Manufacturers Association.

C. ACI — American Concrete Institute, Box 19150, Redford Station, Detroit, Michigan, 48219.

D. ADC — Air Diffusion Council.

E. AGA — American Gas Association.

F. AGMA — American Gear Manufacturers Association.

G. AIMA Acoustical and Insulating Materials Association.

H. AISC American Institute of Steel Construction, 1 East Wacker Drive, Suite 3100, Chicago, Illinois, 60601.

I. AISI American Iron and Steel Institute.

J. AMCA Air Movement and Control Association, 30 West University Drive, Arlington Heights, Illinois, 60004.

K. ANSI American National Standards Institute (formerly United States of America Standards Institute), 1430 Broadway, New York, New York, 10018.

L. API American Petroleum Institute.

M. APWA American Public Works Association.

N. ARI Air Conditioning and Refrigeration Institute, 1815 North Fort Myer Drive, Arlington, Virginia, 22209.

O. ASCE American Society of Civil Engineers.

P. ASHRAE American Society of Heating, Refrigerating and Air Conditioning Engineers, 1791 Tullie Circle, N.E., Atlanta, Georgia, 30329.

Q. ASME American Society of Mechanical Engineers, 345 East 47th Street, New York, New York, 10017.

R. ASTM American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania, 19103.

S. AWI Architectural Woodwork Institute.

T. AWPA American Wood Preserver’s Association.

U. AWPI American Wood Preserver’s Institute.

V. AWS American Welding Society, 550 N.W. Lejuene Road, Miami, Florida, 33126.

W. AWWA American Water Works Association, 6666 West Quincy Avenue, Denver, Colorado, 80235 and 2310 South Walter Reed Drive, Arlington, Virginia, 22206.

X. CAGI Compressed Air and Gas Institute.

Y. CBM Certified Ballast Manufacturers.

Z.	CBR	California Bearing Ratio.
AA.	CISPI	Cast Iron Soil Pipe Institute.
BB.	CMAA	Crane Manufacturers Association of America.
CC.	CS	Commercial Standard, United States Department of Commerce.
DD.	CSS	Cationic Slow Setting Asphalt Emulsion.
EE.	CTI	Cooling Tower Institute.
FF.	DFPA	Douglas Fir Plywood Association.
GG.	EIA	Electronic Industries Association.
HH.	EPA	United States Environmental Protection Agency.
II.	ETL	Electrical Testing Laboratory.
JJ.	Fed Spec	Federal Specification.
KK.	FM	Factory Mutual System, 1151 Boston Providence Turnpike, Norwood, Massachusetts, 02062.
LL.	FPS	Fluid Power Society.
MM.	FS	Federal Specifications.
NN.	HI	Hydraulic Institute.
OO.	HMI	Hoist Manufacturers Institute.
PP.	IAPMO	International Association of Plumbing and Mechanical Officials.
QQ.	IBC	International Building Code.
RR.	ICBO	International Conference of Building Officials, 5360 South Workman Mill Road, Whittier, California, 90601.
SS.	IEEE	Institute of Electrical and Electronic Engineers.
TT.	IES	Illuminating Engineering Society.
UU.	IFC	International Fire Code.
VV.	IMC	International Mechanical Code.
WW.	IPCE	International Power Cable Engineers Association.

XX. IPCEA Insulated Power Cable Engineers Association.

YY. ISA Instrument Society of America.

ZZ. MSS Manufacturer’s Standardization Society (Note: Also used for Boeing’s Maintenance Service System).

AAA. NAPF National Association of Plastic Fabricators.

BBB. NBS National Bureau of Standards.

CCC. NEBB National Environmental Balancing Bureau, 8224 Old Courthouse Road, Vienna, Virginia, 22180.

DDD. NEC National Electric Code.

EEE. NEMA National Electrical Manufacturer’s Association, 2101 L Street, N.W., Washington, DC, 20037.

FFF. NFPA National Fire Protection Association, 1619 Massachusetts Avenue, N.W., Washington, DC, 20036.

GGG. NSF National Sanitation Foundation.

HHH. OSHA Occupational Safety and Health Act.

III. PCA Portland Cement Association.

JJJ. PDI Plumbing and Drainage Institute.

KKK. PS Product Standard, United States Department of Commerce.

LLL. SDI Steel Deck Institute.

MMM. SJI Steel Joist Institute.

NNN. SMACNA Sheet Metal and Air Conditioning, Contractors’ National Association, 8224 Old Court House Road, Vienna, Virginia, 22180.

OOO. SPR Simplified Practice Recommendations, United States Department of Commerce.

PPP. SSPC Structural Steel Painting Council.

QQQ. UL Underwriters’ Laboratories, Inc., 333 Pfingston Road, Northbrook, Illinois, 60062.

RRR. WCLIB West Coast Lumber Inspection Bureau.

SSS. WIC Woodwork Institute of California.

TTT. WISHA Washington Industrial Safety and Health Act.

UUU. WSS Washington State Standard Specifications for Road and Bridge and Municipal Construction.

VVV. WWPA Western Wood Products Association.

1.5 CONTRACT DOCUMENTS ABBREVIATIONS

A. General: Refer to the Contract Drawings for additional lists of abbreviations and their definitions as used in the drawing noted and in the Specifications. The abbreviations, where used, shall have full force as if the word or the words had been used. Where an abbreviation has more than one definition, the correct definition is determined by the context in which it is used. Standard English abbreviations, Such as Ave. for Avenue, St. for Street, etc., have not been listed and shall have their standard definitions. Abbreviations pertaining to and unique to mechanical and electrical work are defined in those respective divisions of the specifications.

2. PRODUCTS

(Not Used)

3. EXECUTION

(Not Used)

* * * END OF SECTION * * *

SECTION 01110

SUMMARY OF WORK

1. GENERAL

1.1 GENERAL DESCRIPTION

A. Contractor shall provide Boeing with the timely performance of the Work, including construction services, consultation, advice and other associated services in full compliance with the Contract Documents, including but not limited to the Scope of Work so as to complete the Work by the Completion Date. All Work provided to Boeing shall be performed in full compliance with the Contract Documents.

1.2 OVERVIEW DESCRIPTION

A. The Work to be provided includes all other deliverables to be provided to Boeing, as well as, any such consultation, advice and other services as may reasonably be required in support of the completion of the Work, throughout the course of the Contract including any required extensions of the Schedule. In addition, Contractor agrees and understands that it is intended that the Contract Documents, taken as a whole, require Contractor to furnish all necessary services, sufficient labor, qualified personnel, Materials, tools, Equipment, plant, other necessary items and supervision required to complete the Work described in the Contract at no additional cost to Boeing. Contractor is responsible for the proper operation and maintenance of all equipment, systems, and their components until these requirements have been met and until final acceptance of the Work by Boeing.

1.3 PROJECT DESCRIPTION

A. Contractor shall furnish all supervision, labor, material, and equipment to complete the NBF PEL REMEDIATION project specifically including, but not limit to, the following:

1. Bid documents are based upon 60 % design drawings. Selected contractor will work with Boeing and URS Engineering through the completion of the 90% and 100% design packages to finalize construction work plans, schedules, and ordering of materials. <u>In addition, contractor will participate in pre-construction meetings to define, coordinate, and clarify project requirements for security, environmental issues, traffic control, etc.</u>
2. Design milestones are listed below. The construction start date is projected to occur on June 13, 2011- prior to the issuance of the 100% design package.
3. <u>Phase 1 – Relocate Utilities for Soil Remediation (Drawings to be issued at a later date).</u>

a. Installation of approximately 400 feet of 1,000 psi compressed air piping. New piping is replacement of existing piping removed by others for soil remediation east of building 3-323. Scope of work includes welded tie-in to existing piping at each end and start-up / commissioning of air line.

b. Installation of a new shut-off valve in existing fire line to King County fire hydrant # 340.

4. Phase 2 – Re-route Stormwater Lines

a. Complete underground storm water system as detailed on URS design drawings titled 3-YD Phase 2 Re-Route Storm Lines , dated April 26, 2011 including :

1) Approximately 2000 lf of gravity-fed stormwater piping from new tie-in to existing King County stormwater manhole north of 3-323 building (Reference URS drawing C308) to existing manhole MH 422 at new waste treatment facility south of 3-380 building (Reference URS drawing C296).

2) Approximately 1600 lf of pump-fed stormwater piping from connection point at existing MH130A, NE of the 3-350 building
(Reference URS drawing C301) to existing lift station south of 3-380 building (Reference URS drawing C296).

3) Structural concrete pad, utility connections, including electrical service, to Boeing purchased waste water treatment facility to be located south of 3-380 building. Waste water treatment facility will be installed and commissioned by others. (Reference Landau Associates drawings titled “Long-Term Stormwater Treatment Plant.”).

b. Saw cut and removal of existing asphalt and concrete paving as required for installation of new stormwater system.

c. Asphalt and concrete paving patching as required. Patching shall be performed in phases to complete sections of installation as work progresses. All work will be performed per Boeing standards.

d. Stockpiling of excavated soil in designated stockpile areas. Soil to be tested for contaminants by Boeing Environmental prior to disposal or re-use.

e. Dewatering.

f. Utility locating and marking.

2. PRODUCTS

(Not Used)

3. EXECUTION

(Not Used)

* * * END OF SECTION * * *

SECTION 01300

SUBMITTAL PROCEDURES

1. GENERAL

1.1 GENERAL REQUIREMENTS

A. Contractor shall submit to Boeing Contractor Drawings, data, and samples for review whenever:
   1. Required by the Contract Documents,
   2. For any Work that Contractor wants to perform in a manner significantly different from the manner indicated in the Contract Documents,
   3. If substitutions require rearrangement of portions of the Work, or
   4. If coordination drawings are created to coordinate Subcontractor Work. Contractor shall submit sufficient copies of data, samples, and Contractor Drawings for Boeing to retain four (4) copies plus the number of copies deemed necessary for use by the Contractor and Subcontractor.

B. Neither review by Boeing of such data, samples, and Contractor Drawings nor permission from Boeing to proceed shall constitute acceptance or approval of design details, calculations, analyses, test methods, certificates, or Materials developed or selected by Contractor or construction or installation procedures or otherwise relieve Contractor of its responsibility to fully comply with the Contract Documents.

1.2 DRAWINGS

A. Contractor shall prepare and submit to Boeing for approval by Boeing, coordination drawings as required by the Technical Specifications.

B. If Contractor Drawings are required for fabrication of Contractor-furnished Materials, installation of Contractor-furnished Material, or planning and/or performance of the Work, such Contractor Drawings shall be submitted before fabrication, installation, or performance commences, allowing ample lead time to avoid delay of the Work.

C. Before submittal to Boeing, the Contractor shall review the submittal and shop drawings for completeness and indicate its review and acceptance by affixing to all copies a stamp of the Contractor's name, which is executed by the appropriate Contractor representative. Submittals and shop drawings that have not been reviewed and accepted by the Contractor will not be accepted by Boeing. Unless otherwise specified in the Contract, Boeing will review the Contractor Drawings, pursuant to Section 3.1 (Boeing Review of Drawings, Samples, Certificates and Data).

1.3 SAMPLES

A. If samples are required by the Contract Documents, they shall be submitted by Contractor, allowing ample lead time to avoid delay of the Work. Samples shall be subject to review by Boeing. Materials represented by such samples shall not be manufactured, delivered to the Site, or incorporated into any Work before such review and authorization to proceed, pursuant to Section 3.1 (Boeing Review of Drawings, Samples, Certificates and Data).

B. Each sample shall bear a label showing Contractor's name, the Project name, and name of the item, manufacturer's name, brand name, model, Supplier's name and reference to the appropriate Contractor Drawing, and the appropriate section and paragraph number in any technical specifications supplied by Boeing.

1.4 CERTIFICATES

A. If certificates are required for the Work by the Contract Documents or by applicable law, the number of copies required by the Contract Documents shall be submitted to Boeing, allowing ample lead time to avoid delay of the Work. Certificates shall be subject to review by Boeing. Material represented by such certificates shall not be fabricated, delivered to the Site, or incorporated into any Work before such review and authorization to proceed, pursuant to **Section 3.1 (Boeing Review of Drawings, Samples, Certificates, and Data)**.

B. Certificates shall clearly identify the material being certified and shall include, without limitation, the following information: Contractor's name, the Project name, name of the item, manufacturer's name, reference to the appropriate Contractor Drawing, and the appropriate section and paragraph number in any technical specifications supplied by Boeing.

2. PRODUCTS

(Not Used)

3. EXECUTION

3.1 BOEING REVIEW OF DRAWINGS, SAMPLES, CERTIFICATES, AND DATA

A. Contractor shall forward submittals of Contractor Drawings, samples, certificates, and data to the Boeing Administrator for technical review. Submittals will be returned with the review stamp indicating actions to be taken.

B. The return to Contractor of a submittal with notations will indicate the actions required of the Contractor. If the notation indicates "No Exception Taken," "Reviewed as Noted," or similar wording, the Contractor Drawings have been accepted by Boeing and Contractor will be authorized to proceed with the Work or procurement contemplated by the submittal on receipt of a Notice to Proceed.

C. If any submittal is returned to Contractor with notations indicating that corrections are required, Contractor shall correct and resubmit for review. Contractor is NOT authorized to proceed based on the original submittal. Contractor shall be responsible for, and bear all costs of, damages that may result from the ordering of any material or from proceeding with any part of the Work before review by Boeing of any prerequisite submittal and return from Boeing with a notation authorizing Contractor to proceed.

D. Contractor shall comply with any instructions in the transmittal letter accompanying any submittal returned. Contractor shall be responsible for, and bear all costs of, damages that may result from the ordering of any material or from proceeding with any Work other than in accordance with any transmittal letter.

E. Review by Boeing of Contractor's submittals of Contractor Drawings, samples, certificates, or other data shall not relieve Contractor of any obligations under the Contract Documents or relieve Contractor of its responsibility for the correctness of such Contractor Drawings, samples, certificates, or other data. Contractor shall accomplish any changes that are necessary to make the Work conform to the provisions of the Contract.

* * * END OF SECTION * * *

SECTION 01310

PROJECT MANAGEMENT AND COORDINATION

1. GENERAL

1.1 CONTRACTOR REPRESENTATIVE

A. Before commencing any Work, Contractor shall designate a competent, authorized representative ("Contractor Representative") acceptable to Boeing to represent and act for Contractor and shall notify Boeing of the name and address of such representative. Such notice shall clearly specify in writing all limitations of the Contractor Representative's authority in representing and acting for Contractor. Subject to any such limitation, all notices, determinations, instructions, and other communications given to Contractor Representative by Boeing shall be binding on Contractor. Contractor Representative shall be present or be duly represented at the Site at all times when Work is actually in progress. Contractor shall notify Boeing in writing before any change in the designated Contractor Representative or imposition of any limitation on Contractor Representative's authority. Contractor shall coordinate with the Boeing Authorized Purchasing Representative to ensure that Field Orders and any other Changes in Contract, including the value or scope, will be coordinated with the Boeing Authorized Purchasing Representative and the Contract will be formally amended as necessary.

1.2 COORDINATION ON SITE

A. Boeing and other contractors, subcontractors, or suppliers may be working at the Site during Contractor's performance of the Work (Joint Occupancy), and such concurrent activities may interfere with the Work. Boeing will endeavor to coordinate the Work and the work of all other suppliers and contractors in a manner consistent with the orderly and expeditious performance and completion of the entire Project so as to minimize interference with or suspension of the Work or any other work. Contractor shall and shall ensure that its Subcontractors and Suppliers shall fully cooperate with such other contractors, subcontractors, and suppliers to avoid any delay or hindrance of their work. Boeing may require that certain facilities be used concurrently by Contractor and other contractors. Contractor shall schedule all Work to avoid interruption of and interference with Boeing operations and work schedules in the work areas at and adjacent to the Site. In the event of scheduling disputes among those working on the Site, the matter shall be submitted to the Boeing Administrator for resolution, whose determination shall be binding and shall be promptly implemented.

1.3 WORK DEPENDENT ON OTHERS

A. If proper execution of the Work depends, in part, on actions by Boeing or work of a separate contractor, the Contractor shall, before proceeding with that portion of the Work, promptly report to the Boeing Administrator any apparent discrepancies or defects in such other construction or any situation that would adversely affect Contractor's Work. Failure of the Contractor to report such a circumstance shall constitute acknowledgment that Boeing or the other contractor had completed their work s so that it is fit and proper to receive the Contractor's Work, except as to defects not then reasonably discoverable. Costs caused by delays or by improperly timed activities or by defective construction by Contractor or others shall be borne by the responsible party as provided. The Contractor shall promptly remedy damage caused by the Contractor to completed or partially completed work of others.

1.4 NON-INTERFERENCE

A. Contractor acknowledges that Boeing may, if permitted by applicable law and governmental authority having jurisdiction, conduct its office and other operations at the Site, and Contractor agrees not to interfere in any manner whatsoever with such office and other business operations and, at the request of the Boeing Administrator, to fully cooperate with Boeing in scheduling any portion of the Work to accommodate such office and other business operations of Boeing.

2. PRODUCTS

(Not Used)

3. EXECUTION

(Not Used)

* * * END OF SECTION * * *

SECTION 01320

CONSTRUCTION PROGRESS DOCUMENTATION

1. GENERAL

1.1 SCHEDULE

A. Adherence to Schedule

1. Contractor shall complete all Work as required to meet the Contract Time and any milestone dates set forth in the Contract Documents. Contractor shall perform the Work as expeditiously as is consistent with professional skill and care and the orderly progress of the Project, but in any event, shall deliver the Work Product no later than the Completion Date (including each milestone date, if any) for the Work Product as set forth in the Contract. Contractor shall prosecute the work substantially in accordance with the approved Schedule and failure to do so shall be evidence that Contractor is failing to prosecute the Work with such diligence as will ensure its completion within the time specified in this Contract and may result in termination for default. The Schedule shall include allowances for Boeing's review and approval of submissions by Authorities. Time limits established by the Schedule as approved by Boeing shall not be exceeded by Contractor, except for Excusable Delays. Timely completion of any of the Work required under the Contract is critical as "time is of the essence" and failure to perform timely shall constitute a material breach of this Contract. Contractor acknowledges that Boeing will suffer adverse financial and other consequences if the Work is not completed within the time period established by Boeing.

B. Schedule for Sequencing the Work

1. In the event that the Work is to be separately sequenced or sequenced in phases, Contractor shall develop a schedule for performance of the Work in order to sequence and coordinate properly the Work with the services to be provided by other Boeing designers, contractors and suppliers under separate contracts. This schedule is to be prepared whether or not the services to be provided by other Boeing designers, contractors and suppliers are to proceed concurrently with the Work under this Contract.

C. Staffing to Schedule

1. Contractor shall furnish sufficient forces, construction plant, and Equipment and shall work such hours, including night shifts, overtime operations, and Sunday and holiday work, as may be necessary to ensure the prosecution of the Work substantially in accordance with the approved Schedule. If Contractor falls behind such schedule, Contractor shall take such steps as may be necessary to improve its progress, and Boeing may require Contractor to increase the number of shifts, overtime operations,

days of work, including Saturdays, Sundays, and holidays, and the amount of plant, labor, and Equipment. Such costs are considered to be included in the Contract Price.

1.2 PROGRESS REPORTS

A. During the performance of the Work, Contractor shall submit to the Boeing Administrator periodic progress reports. The progress reports shall include all of the following elements that are applicable to the Work:

1. A copy of the Schedule in the format required by Boeing revised to reflect current progress;
2. Cost reports showing incurred costs and revised estimates of costs to complete the performance of the Work in comparison to the budget;
3. Earned Value Reports comparing the amount of Services completed and the amount of Services billed
4. A list of Equipment used on the Work during the reporting period;
5. A listing of personnel performing the Work at the Site during the reporting period;
6. A forecast of personnel and Equipment for the succeeding thirty (30) days; and
7. Any other pertinent information as requested by the Boeing Administrator.

2. PRODUCTS

(Not Used)

3. EXECUTION

(Not Used)

* * * END OF SECTION * * *

SECTION 01350

SPECIAL PROCEDURES

1. GENERAL

1.1 WASTE MANAGEMENT

A. With respect to recyclable materials and Construction, Demolition and Land Clearing Debris generated by Contractor and its Subcontractors at the Site in performance of the Work, Contractor shall submit to the Boeing Administrator on a quarterly basis a written report which includes the following:

1. A description of all recyclables and non-hazardous waste (including CDL Debris) removed from the Site by Contractor, Subcontractor and Supplier;
2. The quantity of recyclables and non-hazardous waste removed from the Site, by weight, for that period;
3. Classification of the recyclables according to by the following categories:
   a. Concrete, Asphalt and masonry
   b. Clean Soil & Gravel
   c. Metals
   d. Stumps and Brush
   e. Recyclables sorted off-site by a 3rd party provider

B. Boeing shall dispose of all Hazardous Waste generated at the Work Site. Contractor, its Subcontractors, and its Suppliers shall not remove Hazardous Waste from the Work Site. If additional or unanticipated amounts or types of waste are generated or encountered on-Site, the Contractor shall advise the Boeing Administrator as soon as possible and manage the Hazardous Waste on Site as directed by the Boeing Administrator.

1.2 WASTEWATER HANDLING AND STORM WATER MANAGEMENT

A. If Contractor or its Subcontractors or Suppliers expect to produce wastewater in performance of the Work, including water produced in subsurface dewatering, or expect to handle Hazardous Materials in an area that may be exposed to storm water, Contractor shall develop a written plan to be approved by the Boeing Administrator for handling such wastewater or storm water. Both the control and discharge of wastewater and /or storm water shall be addressed in Contractor's plan. Such plan shall be drafted to adhere to applicable law and the Boeing's Site's Storm Water Pollution Prevention Plan, National Pollution Discharge Elimination System Permit (NPDES), and Sanitary Sewer System Discharge Permit, as applicable. The Boeing Administrator will inform the Contractor of such permit requirements. The Contractor and its Subcontractors and Suppliers shall adhere to the plan.

B. If the Work of the Contractor or its Subcontractors or Suppliers requires a new National Pollutant Discharge Elimination System ("NPDES") permit or any other permit, the Contractor shall work with the Boeing Administrator to ensure that an appropriate NPDES permit application is completed. Any permit prepared by the Contractor shall be submitted to Boeing for review before the permit is submitted to a government agency. Unless otherwise directed by the Boeing Administrator, the Contractor must be listed as the permittee or co-permittee on the permit if the state in which the permit is issued allows contractors to serve as permittees in conjunction with or in lieu of the owner of the site.

1.3 PROTECTION AND MAINTENANCE OF WORK AND PROPERTY

A. Security of property

1. Contractor shall at all times perform the Work, and all operations related thereto, so as to avoid the risk of loss, theft, or damage to any property by vandalism, sabotage, other construction activities, or other means. Contractor shall be solely responsible for inspecting the Site, the Work and any Materials, Equipment, and facilities to be incorporated into, or used for, the Work, in order to discover any conditions that create a risk of loss, theft, or damage to property. Contractor shall promptly take all action needed to alleviate any such risk. In addition, Contractor shall comply with any security procedures or requirements established by Boeing. Contractor shall prepare and maintain for at least one (1) year after final acceptance of the Work, accurate reports of any loss, theft, or vandalism. Contractor shall furnish such reports to the Boeing Administrator in a timely manner.

B. Watchman

1. Unless otherwise agreed to by the parties, Boeing will not arrange for a security or watchman service for the Work or the Site. Contractor shall be responsible for and will promptly advise the Boeing Administrator of any theft or damage that might delay the execution of the Work.

C. Fire Prevention

1. If requested by Boeing, Contractor shall submit a plan for fire prevention and fire protection to Boeing for review. Such review by Boeing shall not relieve Contractor of its obligations for safety nor create any liability for Boeing. Contractor shall not perform any cutting, welding, burning, or flame- or spark-producing operations without prior written approval from Boeing. If any permit is required for such work, such permit shall be obtained before the operation takes place. Contractor shall place at each work area on the Site portable fire extinguishers that are appropriate for any fire hazard that exists at such work area and shall instruct its employees, and the employees of any Subcontractor, of their location and use. If cutting, welding, burning, or flame- or spark-producing operations are conducted, flammable Materials shall be protected in accordance with applicable permit requirements, and the Contractor will arrange for a fire watch to be present during and for an appropriate time after the operation to ensure that protective measures are taken and that no fires result from

such operation. The fire watch shall have fire extinguisher equipment readily available and shall be skilled in its proper use. Contractor shall notify the Boeing Administrator before it stores any flammables in the Contractor's staging area. If required by the Boeing Administrator, the Contractor shall furnish approved storage equipment for such flammables.

D. Disruption, Closure, Obstruction, or Damage

1. Contractor shall not commence Work involving the disruption of the operation of any Utility or the closure, obstruction, or damage to any Utility, highway, road, ditch, structure, storm water drainage systems, temporary or permanent sedimentation and erosion control systems, Site security fencing, other construction Work, or other property, whether or not located on the Site, until it obtains all necessary permits and written approval from Boeing to commence such Work. Contractor shall perform all other work so as not to disrupt the operation of any Utility or close, obstruct, or damage any Utility, highway, road, ditch, structure, storm water drainage systems, temporary or permanent sedimentation and erosion control systems, Site security fencing, other construction work, or other property. In the event of any disruption of any Utility or closure, obstruction, or damage to any Utility, highway, road, ditch, structure, storm water drainage systems, temporary or permanent sedimentation and erosion control systems, Site security fencing, other construction work, or other property, whether or not required for the Work, Contractor shall promptly make all repairs necessary to return it to its former condition. Before completing such repairs, Contractor shall arrange for temporary guards, lights, other signals, and temporary repairs as needed for safety in a manner acceptable to Boeing. Unless otherwise agreed to in writing by the parties, Contractor shall be responsible for the costs and time of the repairs, temporary guards, lights, other signals, and temporary repairs required. Contractor shall not be entitled to any increase in the Contract Price and/or the Contract Time resulting from the existence or the disruption, closing of, or damage to any Utility, highway, road, ditch, structure, storm water drainage systems, temporary or permanent sedimentation and erosion control systems, Site security fencing, other construction work, or other property, whether or not on the Site.

E. Protection of Plants

1. Contractor shall preserve and protect all cultivated and planted areas and all vegetation (including trees, plants, shrubs, and grass) on or adjacent to the Site, which, as determined by Boeing, do not unreasonably interfere with the performance of the Work. Unless otherwise agreed to in writing by the parties, Contractor shall be responsible for all costs and time in connection with any repairs or restoration needed by reason of any damage to any such areas or vegetation or due to unauthorized cutting of vegetation, including damage arising from the performance of the Work through operation of Equipment or stockpiling of Materials.

F. Snow, Ice, Dirt, and Mud Removal

1. Contractor shall remove snow and ice to the extent necessary to perform the Work. Calcium chloride or other chemicals as aids or means to remove snow or ice will not be permitted. Contractor shall ensure that vehicles are constructed, loaded, maintained, and covered as necessary to prevent deposition of dirt, mud, or other debris on public roadways. Dirt, mud, and debris removal shall be undertaken on a continual basis. Dirt, mud, or debris dropped or otherwise deposited onto streets by vehicles involved in the Work shall be immediately removed.

G. Dust Control

1. At all times during the Work, Contractor shall take all necessary steps to effectively control dust in the working area, unpaved roads used in the operations, and other portions of the Site. Such dust control shall not include application of calcium chloride or any other chemicals but shall include intermittent watering and sprinkling at such frequency as will satisfactorily settle the dust. Contractor shall also comply with any requirements imposed by law to prevent fugitive dust emissions.

H. Spray Painting of Buildings and Structures

1. Spray painting of buildings or structures shall be conducted only as allowed by applicable air pollution control laws, including any site specific permits, approvals or authorizations. Contractor shall notify the Boeing Administrator seven (7) days before all spray painting and shall obtain the Boeing Administrator's prior written approval of any paint spraying. The painting area must be well ventilated and completely sealed off with approved tarps. Any Visqueen must be of a fire-retardant variety.

I. No Smoking

1. Smoking is prohibited at the Site at all times unless otherwise notified by Boeing in writing.

1.4 SAFETY

A. Safety Programs and Plans

1. Although Contractor has sole responsibility for safety in connection with the Work, Boeing has responsibility for the safety of its own employees. Accordingly, before beginning the Work, Contractor shall develop and submit for review by Boeing written project-specific safety plans in detail commensurate with the nature of the Work. Such plans shall describe anticipated hazards and control methods the Contractor will employ as adequate safeguards for all employees performing the Work, Work area invitees, Boeing's agents and employees, and the public. An appropriate health or safety professional should prepare such plans. Contractor's project-specific safety plans shall be made readily available at the work area. Contractor shall follow its project-specific safety plans and ensure

that all its Subcontractors and Suppliers on Site follow the Contractor's project-specific safety plans. Review of such plans- by Boeing shall not:

a. Relieve in any manner Contractor of its sole responsibility for safety;
b. Be construed as limiting in any manner Contractor's obligation to undertake any action that may be necessary or required to establish and maintain safe working conditions at the work area; or
c. Indicate Boeing's control over the manner in which Contractor performs it's Work or supervises its employees.

B. Safety Representative

1. Contractor shall appoint a competent safety representative with full authority to coordinate, implement, and enforce Contractor's project-specific safety plans and shall authorize such representative to devote whatever time is necessary to properly perform such duties. The safety representative shall attend all Project safety meetings and participate fully in all activities outlined in Contractor's project-specific safety plans.

C. Safety Meetings

1. Contractor shall hold regularly scheduled meetings to instruct its personnel and all personnel of Subcontractors and Suppliers in safety practices for the Work. Minutes shall be recorded at all safety meetings and copies promptly submitted to Boeing on request.

D. Accident Reports

1. Accidents and incidents occurring on property owned, leased or controlled by Boeing that involve property damage or employee time away from Work or medical treatment (not including first aid cases) or incidents that require an ambulance, security, or fire department response must be reported to the designated Boeing Administrator immediately and followed up in writing within eight (8) hours or by the end of the shift, whichever is sooner, of the accident or incident. Contractor shall maintain accurate accident and injury reports and shall furnish to Boeing a copy of any accident report prepared pursuant to any applicable law. Contractor shall also furnish to Boeing, in a form acceptable to Boeing, a monthly summary of injuries and hours worked each month.

E. Payment for Emergency Work

1. When any employee of Contractor or any Subcontractor or Supplier on site, who is engaged in any activity related to the Work, requires the services of an ambulance, physician, hospital, or other provider, Contractor shall pay or arrange for such Subcontractor or Supplier, to pay all charges for any such services directly to the provider of such services.

F. Emergency Notification

1. All emergency telephone numbers shall be provided to the Boeing representative and shall be readily accessible at the work area.

G. Excavation Below 12 inches

1. The Contractor shall use applicable site drawings to identify all underground utilities in the excavation area. After all known utility lines have been identified, Contractor shall then use underground testing equipment to accurately locate all utilities in the excavation area. The Contractor shall use a locater that complies with the Professional Competence Standard for Locating Technicians (National Underground Locating Contractors Association). The Contractor shall ensure that all identified utility lines are marked and labeled in compliance with the American Public Works Association standards. The Contractor shall notify Boeing of utilities not shown on existing site drawings
2. Once the utilities are properly marked in the excavation area, the Contractor may begin the excavation work. Appropriate mechanical means may be used except that hand tools and hand dig methods must be used when digging within 24 inches of any utility.

H. Lockout/Tag out

1. In addition to the requirements set forth in the Boeing Service Provider Manual, Contractor shall have a written lockout/tag out plan.

2. PRODUCTS

(Not Used)

3. EXECUTION

(Not Used)

* * * END OF SECTION * * *

SECTION 01450

QUALITY CONTROL

1. GENERAL

1.1 QUALITY, SURVEILLANCE, INSPECTION AND REJECTION OF MATERIALS AND WORKMANSHIP

A. Boeing Quality Surveillance

1. All Materials furnished and Work performed shall be properly inspected by Contractor and shall at all times be subject to quality surveillance by Boeing. Contractor shall provide safe and appropriate facilities and make available all designs, samples, drawings, lists, and documents that are necessary for such quality surveillance. Boeing shall be afforded full and free access to the shops, factories, or places of business of Contractor and all Subcontractors and Suppliers in order to allow Boeing to perform such quality surveillance and to determine the status of the Work. If Contractor covers all or any portion of the Work before any scheduled quality surveillance or testing by Boeing, Contractor shall be responsible for the cost of any uncovering and replacing needed in order to allow such surveillance or testing.

B. Rejection

1. In the event that during performance of any portion of the Work but before such time Contractor has given Boeing written notice that such Work is complete and ready for final acceptance, Boeing determines that such Work, including Materials, workmanship, or documentation is defective or does not comply with the requirements of the Contract Documents, Boeing shall notify Contractor of such determination. Immediately after receipt of such notice, Contractor shall, at Contractor's sole cost and expense, remove and replace or correct such defective Work so that the replaced or corrected Work complies strictly with all requirements of the Contract Documents.

2. PRODUCTS
(Not Used)

3. EXECUTION
(Not Used)

* * * END OF SECTION * * *

SECTION 01500

TEMPORARY FACILITIES AND UTILITIES

1. GENERAL

   A. Assignment of Work Area at the Job Site
      1. All of Contractor's work areas on the Site will be assigned by Boeing. Contractor shall confine its office, shops, storage, assembly, Equipment, Materials, and vehicle parking to the areas so assigned. Should Contractor find it necessary or advantageous to use any additional area outside the Site for any purpose whatever, Contractor shall obtain the approval of the Boeing Administrator before arranging for the use of such additional area, which additional area shall be at Contractor's sole expense.

   B. Contractor's Staging Area
      1. Contractor agrees to confine all its operations including storage; company vehicle unloading; and movement of Materials, Equipment, and workers to the staging area designated by the Boeing Administrator. Contractor shall be responsible for securing all Equipment and Materials used on the Work and shall provide the necessary tool boxes, fencing, and any other facilities necessary for such protection.

   C. Contractor's Parking Areas
      1. Parking on Site, if available, for Contractor's or its Subcontractor's or Supplier's trucks and service vehicles will be limited to the Contractor's staging area. This parking will be available only for a limited number of Contractor vehicles. All other personal vehicles are to be parked in off-site commercial general parking lots at Contractor's expense.

   D. Contractor's Construction Plant, Equipment and Facilities
      1. Information and Drawings
         a. Before proceeding with the erection or use of any construction plant, Equipment, or facilities in connection with the Work, including temporary structures, machinery, offices, and warehouses, Contractor shall furnish Boeing with any information and drawings relative to such construction plant, Equipment, and facilities that Boeing may reasonably request.
      2. Requirements
         a. Contractor shall provide and use only such construction plant, Equipment, and facilities as are capable of producing the quality and quantity of Work and Materials required by the Contract Documents, within the Contract Time, and at times specified in the Schedule. On notice by Boeing, Contractor shall discontinue operation of any construction plant, Equipment, or facilities that are not satisfactory to Boeing and shall either modify the

unsatisfactory items to meet approval by Boeing or remove the unsatisfactory items from the Site. Contractor shall not remove any construction plant, Equipment, or facilities from the Site before final acceptance by Boeing of the Work without written approval by Boeing. Such approval shall not be unreasonably withheld. Unless stipulated otherwise in the Contract Documents, all Utilities and facilities required for the Work including power, sanitary facilities, telephones, and construction and drinking water will be provided by the Contractor.

2. PRODUCTS

(Not Used)

3. EXECUTION

(Not Used)

* * * END OF SECTION * * *

SECTION 01570

TRAFFIC REGULATION

1. GENERAL

1.1 TRAFFIC CONTROL

A. Routing of new storm lines and locations of new manholes will be in areas of high Boeing pedestrian and vehicle traffic. Contractor shall be responsible for providing all safety signage, flagging, barricades, etc. as required to isolate construction work from Boeing activities and personnel.

B. Contractor shall be responsible for site control during construction and shall provide signage and fencing so that access is limited to construction personnel. Signs to be clearly visible at critical areas on the site and shall be maintained daily with updates regarding contractor activities

C. Routing of the new storm water system requires crossing through the NBF perimeter security fence and crossing the roadway at the Myrtle Street entrance (Gate C50). Contractor shall coordinate installation of underground piping in this area to comply with the requirements of the Boeing Security Department.

2. PRODUCTS
(Not Used)

3. EXECUTION
(Not Used)

* * * END OF SECTION * * *

SECTION 01600

PRODUCT REQUIREMENTS

1. GENERAL

1.1 MATERIALS AND QUALITY

A. Unless otherwise specifically provided in the Contract, reference to any material or patented process by trade name, make, or catalog number, whether or not with the words "or equal" or words of similar meaning, shall be regarded as establishing a standard of quality and shall not be construed as limiting competition. Contractor is required to provide only new Material and may substitute any material or process that Boeing determines is equal to the material or process referenced. All substitutions, including "or equal" items, must have the prior written approval of Boeing. Certain items may be indicated as "no substitutions" in which event substitutions will not be accepted. When required by the Contract or by Boeing, Contractor shall promptly furnish to Boeing for approval all information concerning, and samples of, the Materials to be incorporated into the Work. Boeing shall have the right to reject any Materials installed or used without the approval required by this Section (Materials and Quality) or that do not comply with the project requirements, in which event the Materials shall be removed at Contractor's sole cost and expense. Approval by Boeing pursuant to this Section (Materials and Quality) shall not relieve Contractor of any obligations under the Contract, including those related to warranties.

2. PRODUCTS
(Not Used)

3. EXECUTION
(Not Used)

* * * END OF SECTION * * *

SECTION 01660

TESTING, TRAINING AND COMMISSIONING

1. GENERAL

1.1 TESTING

A. Testing Schedule

1. The Contractor will submit a job-specific test schedule subject to approval by the Boeing Administrator. The test schedule shall recognize the difference between test agency and Contractor tests, repetitive and daily tests, observations in the field, and system or operational tests; also between factory testing of equipment and On-Site equipment testing. The test schedule shall include as a minimum:
    a. A list of all tests to be performed as required by Contract specifications, applicable codes, or industry standards,
    b. Procedures for each testing operation,
    c. Information on test equipment and its calibration,
    d. Frequency of repetitive tests,
    e. Samples of forms for reporting test results to Boeing,
    f. Schedule of test dates and durations, and
    g. Procedures for notifying Boeing of any test.

B. Twenty-four (24) hour notice will be required for On-Site testing. The schedule provided hereunder will not substitute as proper notice.

C. Shop and Field Testing

1. Unless otherwise specifically provided in the Contract Documents, shop and field testing of the Work or other components of the Work shall be performed by Contractor in accordance with the Technical Specifications. The cost of such testing shall be included in the Contract Price. Contractor shall give Boeing enough prior notice of any such tests to allow a Boeing observer to be present. The Contractor shall perform field testing of the Work, including field testing of Materials used therein. Should tests in addition to those conducted by Contractor be desired by Boeing, Contractor will be advised in reasonable time to permit such testing. Such additional tests will be performed by Contractor or third parties approved or requested by Boeing at the expense of Boeing. Unless otherwise specifically indicated in the Contract Documents, Boeing may elect to perform field testing of the Work, including Materials used therein, in addition to that required of the Contractor. Contractor shall supply any necessary Equipment required to allow access to the testing area. As provided in the Technical Specifications or as requested by Boeing, Contractor shall furnish samples and give reasonable assistance and cooperation in order to permit Boeing to test, or have tests performed,

on Materials or Work in place, including reasonable stoppage of Work during such testing. Contractor shall be responsible for any additional cost of performing any such tests if the Work is not ready for the performance of such tests at the time specified by Contractor because the fault of Contractor.

1.2 TRAINING

A. Contractor shall train Boeing employees in the safe and proper operation and maintenance for each and every piece of equipment, system, and/or system element installed under this Contract. Within thirty (30) days after issuance of Notice of Award and/or Notice to Proceed, Contractor shall submit to Boeing for review and approval a detailed training plan of the required training for the safe and proper operation and maintenance of the equipment and/or system elements and a proposed table of contents for the O&M Manuals.

2. PRODUCTS

(Not Used)

3. EXECUTION

(Not Used)

* * * END OF SECTION * * *

SECTION 01730

OPERATING AND MAINTENANCE INFORMATION

1. GENERAL

1.1 Operation and Maintenance ("O&M")

A. Prior to any Contractor submitting the Notice of Substantial Completion for all or any part of the Work, Contractor will submit Operation and Maintenance Manuals ("O & M Manuals"), nonstandard tools, spares and training for all equipment and systems installed in the Work. The provisions of this subsection do not apply to Boeing-furnished equipment.

B. O & M Manuals.

1. Within thirty (30) days after issuance of the Notice to Proceed or fifteen (15) days before the request for Final Inspection, whichever date is earlier, Contractor shall submit to Boeing for review and approval a proposed table of contents for the O&M Manuals. Prior to submission of the Notice of Substantial Completion, Contractor shall provide Boeing with seven (7) copies of the O&M Manuals in new three-ring binders labeled with the Project name, contract number, and building number. These O&M Manuals shall include the original warranties, operating instructions, working drawings, spare parts lists, performance curves, maintenance and parts manuals, equipment and system element drawings and other operating and maintenance information. All documentation contained in the O&M Manuals shall be legible originals written in English; copies will not be acceptable. O&M Manuals shall contain a Contacts List of contact persons' names, phone numbers, facsimile numbers, electronic mail addresses, and street addresses for Contractor and all Suppliers and Subcontractors involved with the Work. This list shall be organized by company and shall indicate who (Contractor, Supplier, or Subcontractor) is responsible for the warranty of each piece of equipment and/or system element. O&M Manuals also shall contain a list of all equipment incorporated into the Work, stating the manufacturer's name, model number, and the manufacturer's recommended spare parts list for each piece of equipment and/or system element. All spare parts shall be identified by the original Supplier's part number. Individual pieces of equipment and/or system elements shall be placed in the O&M Manuals in separate sections containing the applicable documentation and information for each.

2. PRODUCTS

(Not Used)

3. EXECUTION

(Not Used)

* * * END OF SECTION * * *

SECTION 01770

CLOSEOUT PROCEDURES

1. GENERAL

1.1 DELIVERABLES AT WORK COMPLETION

A. Upon completion of the Work, Contractor shall provide Boeing with all data, drawings, documents and deliverables required by the Contract Documents. Contractor agrees to provide Boeing all deliverables in the formats (i.e., paper, electronic media or both) requested by Boeing.

1. Nonstandard Tools
    a. Contractor shall provide one (1) each of nonstandard tools required in the normal maintenance, adjustment, use, and operation of the equipment or system element. For small commercial standard equipment or system elements, the information and tools shall be limited to that normally available from the manufacturer.
2. Spares
    a. Contractor shall provide all spares required by the Contract Documents.
3. Punch List
    a. Contractor shall provide a copy of the completed punch list showing which items have been corrected and the scheduled completion date of any items not corrected.

1.2 AS-BUILT DATA

A. During the performance of the Work, Contractor shall maintain on a weekly basis all data necessary to revise any Contract Drawings to conform to the as-built condition of the Work. The Contractor and Subcontractors will have a table dedicated to red lined drawings, the Contractor's superintendent will log in entries, and a signoff sheet will be on the wall above each set of drawings. Such drawings shall include, but not be limited to, all underground Utility lines encountered by Contractor in performing the Work. Promptly after completion of all the Work and as a condition precedent to final acceptance and final payment, Contractor shall deliver to Boeing two (2) complete sets of accurate red lined documents.

1.3 CONDITION PRECEDENT TO FINAL PAYMENT

A. Submittal of the above listed items and other deliverables is considered a contractual requirement and required before final acceptance and final payment. Acceptance of the above-listed items and other deliverable shall not constitute a waiver by Boeing of any irregularity in Contractor's performance and shall not relieve Contractor of responsibility for defects in design or other errors or omissions nor from compliance with all the Contract requirements

2. PRODUCTS

(Not Used)

3. EXECUTION

(Not Used)

* * * END OF SECTION * * *

SECTION 02020

FIELD SURVEYING

1. GENERAL

1.1 DESCRIPTION OF WORK

A. This Section specifies field surveying work requirements.

1.2 SUBMITTALS

A. Procedure: Conform to Specifications Section 01300 - Submittal Procedures.

B. Qualifications of the surveyor.

C. Survey field notes and all survey calculations.

D. Licensed surveys as required by the Engineer.

E. As-Built locations and elevations as required by the Engineer.

1.3 COORDINATES

A. Coordinate points for construction are provided in the Drawings.

1.4 FIELD SURVEYING BY CONTRACTOR

A. The Contractor shall establish control point(s) as necessary, in order to develop and make such additional surveys as needed for construction, such as control lines, slope stakes, clearing limits, settlement markers, stakes for pipe locations, and other working points, lines and elevations. Re-establish any benchmarks and survey control points destroyed.

B. Complete the layout for the Work and be responsible for all measurements that may be required for the execution of the Work to the location and limits prescribed on the Drawings. Perform survey work under the supervision of a Professional Land Surveyor licensed in the State of Washington.

C. Perform all survey monument referencing for tie-out prior to pavement restoration. Check and restore monuments and their casings at completion of the Work.

D. Maintain and preserve stakes and other marks established until authorized by the Engineer to remove them.

E. The Engineer or Owner may require that work be suspended at any time when location and limit marks established by the Contractor are not reasonably adequate to permit inspection of the work.

F. Comply with the survey requirements for all monitoring as specified in other Sections.

G. Provide new replacement monuments and boxes when removed or damaged during construction.

H. Re-establish permanent survey control monuments prior to final inspection.

I. Provide correct line and grade of the pipelines to be installed.

J. Provide requirements of the Record Drawings.

1.5 SURVEYOR QUALIFICATIONS

A. Surveyor shall be a Professional Land Surveyor licensed in the State of Washington.

B. The Engineer and Owner reserve the right to disallow the person(s) selected by the Contractor for surveying. If in the Engineer's or Owner's opinion, the person is not qualified to do the work, the Contractor shall select another surveyor and submit qualifications until a qualified person is approved.

2. PRODUCTS

2.1 (NOT USED)

3. EXECUTION

3.1 GENERAL

A. Perform surveys based on control points or coordinates as shown on the Drawings. Use surveys to establish base lines, line and grade hubs, stake elevations, and other reference and construction points.

B. Replaced monuments shall be set by a Professional Land Surveyor licensed in the State of Washington.

C. In advance of the final or restoration paving, produce survey information required to establish paving elevations, slopes, and cross sections.

D. Perform surveys as necessary to document as-built conditions, including pipe bends, sizes, depths, pipe material, and coordinates prior to backfill.

3.2 REQUIREMENTS FOR STRUCTURES

A. Contractor shall establish a horizontal baseline and benchmark for each structure. Baseline and benchmark locations shall be subject to the approval of the Engineer prior to construction.

B. Contractor shall lay out the work from these lines and points.

3.3 FIELD NOTES

A. Keep in standard bound survey field notebooks using a clear, orderly manner consistent with standard surveying practice. Include titles, numbering, and indexing.

B. Keep a copy of all field notes including references to monuments and property corners. Submit when required by the Engineer.

C. Keep a copy of grade sheets completed prior to permanent pavement restoration. Submit when required by the Engineer.

D. Subject to approval of format by the Engineer, electronic field survey information files may be substituted for paper notebooks, field notes and grade sheets.

* * * END OF SECTION * * *

SECTION 02065

DEMOLITION

1. GENERAL

1.1 DESCRIPTION OF WORK

A. The Contractor shall inspect the site to identify features that remain onsite and require removal or abandonment in-place. Notify the Engineer before proceeding with demolition work not shown on the Drawings.

B. This Section includes, but is not limited to, Demolition work as shown on the Drawings as follows:
   1. Removal and offsite disposal of debris from the construction work area.
   2. Abandoning, filling and plugging designated utilities and pipelines.
   3. Cutting designated pipelines.
   4. Cutting existing 42-inch concrete pipe, removal of cut pipe sections, removal of controlled density fill within pipe, and offsite disposal of materials.
   5. Saw cutting, removal, and offsite disposal of asphalt and concrete pavement.
   6. Removal and offsite disposal of walls and bottom of concrete flume, if needed.
   7. Removal and offsite disposal of walls and bottom of wood flume, if encountered and if needed.
   8. Partial demolition and abandonment of designated catch basins.
   9. Removal and offsite disposal of designated steel bollards.
   10. Removal and offsite disposal of designated concrete pad.
   11. Removal and offsite disposal of designated metal tank and associated metal stand.
   12. Removal and offsite disposal of designated metal evaporative coils (four each).
   13. Removal and offsite disposal of grass, shrubs, and other plant life, if needed.
   14. Excavating topsoil.
   15. Protecting items designated to remain or not designated for removal.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Section 01300: Submittal Procedures.

B. Section 02150: Shoring.

C. Section 02240: Dewatering.

1.3 REFERENCE

A. City of Seattle (COS) Standard Specification Sections referenced in this specification shall be the 2011edition of the COS Standard Specifications for Road, Bridge and Municipal Construction, unless otherwise noted.

1.4 SUBMITTALS

A. Procedure: Conform to Specification Section 01300 - Submittal Procedures.

B. Prepare and submit a complete Demolition Plan including demolition sequencing and scheduling covering each item shown on the Drawings.

C. Submit copy of permits required by local authority, utilities, or regulatory agencies.

1.5 CLOSEOUT SUBMITTALS

A. Project Record Documents: Accurately record actual locations of abandoned utilities and catch basins, subsurface obstructions and buried obstructions.

1.6 QUALITY ASSURANCE

A. Comply with Federal, State and local codes concerning demolition of structures, and the transportation and disposal of materials offsite.

1.7 PROJECT SITE CONDITIONS

A. Owner assumes no responsibility for actual condition of site features or other improvements to be demolished.

B. Contractor shall not sell demolished materials onsite.

2. PRODUCTS

(Not Used)

3. EXECUTION

3.1 EXAMINATION

A. Verify existing conditions before starting demolition work.

B. Identify waste and salvage stockpile areas for placing removed materials.

3.2 PREPARATION

A. Contractor shall locate and mark underground utilities within and surrounding construction areas.

B. Notify affected utility companies before starting work and comply with utility's requirements.

3.3 PROTECTION

A. Locate, identify, and protect utilities indicated to remain, from damage.

B. Protect bench marks, survey control points, and existing structures to remain from damage or displacement.

3.4 REMOVAL

A. Do not burn or bury materials on site. Leave site in clean condition.

B. Continuously clean-up and remove waste materials from site. Do not allow materials to accumulate on site.

3.5 TOPSOIL EXCAVATION AND STOCKPILING

A. Do not excavate wet topsoil.

B. Excavate topsoil from areas to be further excavated, re-graded or re-landscaped, and stockpile for future use in finish grading without mixing with fill materials.

C. Topsoil stockpiles shall not be made higher than 10-feet.

3.6 DEMOLITION REQUIREMENTS

A. Use of explosives is not permitted.

B. Conduct demolition to minimize interference with adjacent improvements.

C. Conduct operations with minimum interference to public or private accesses to occupied adjacent structures. Maintain egress and access at all times.

D. Sprinkle Work with water to minimize dust. Provide water truck, hoses and water connections as required for this purpose.

3.7 DEMOLITION

A. Abandon and plug utilities and underground pipelines as shown on the Drawings. Identify utilities remaining at termination of demolition. Record location of abandoned utilities on Record Documents.

B. Cut and dispose of designated pipelines within manholes as locations shown on the Drawings.

C. Saw cut existing 42-inch pipe in accordance with the Drawings. Contractor shall identify the procedure and determine the saw cut limits for the 42-inch pipe and include in the Demolition Plan. Remove portion of pipe and excavate existing controlled density fill.

D. Remove and dispose of frame and grate of the catch basin and fill the catch basin structure with controlled density fill as shown on the Drawings.

E. Saw cut asphalt concrete pavement in the areas affected by the Work.

F. Demolish and dispose of walls of concrete and wood flumes if the walls interfere with the Work.

G. Remove and dispose of concrete pads, steel bollards, metal tank and associated metal evaporative coils as shown on the Drawings.

H. All cleared and demolished materials shall be removed and disposed of in accordance with Federal, State and local regulations.

3.8 WASTE MATERIAL REMOVAL

A. All foreign materials, buried rubble, abandoned pipes and excess native soil materials that cannot be processed for onsite reuse to uniform moisture and texture necessary to achieve specified densities shall be disposed of by the Contractor at the appropriate waste site.

B. All non-native material must be identified, excavated and disposed in accordance with Federal, State, and local regulations.

* * * END OF SECTION * * *

SECTION 02150

SHORING

1. GENERAL

1.1 DESCRIPTION OF WORK

A. This Section includes, but is not limited to, shoring, cribbing and sheeting required to protect the Work.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Section 01300: Submittal Procedures.

B. Section 02221: Excavating, Backfilling and Compacting for Structures.

C. Section 02222: Excavating, Backfilling and Compacting for Utilities.

D. Section 02240: Dewatering.

1.3 REFERENCE

A. City of Seattle (COS) Standard Specification Sections referenced in this specification shall be the 2011edition of COS Standard Specifications for Road, Bridge and Municipal Construction, unless otherwise noted.

1.4 SUBMITTALS

A. Procedure: Conform to Specification Section 01300 - Submittal Procedures.

B. Contractor shall provide and submit a Shoring, Sheeting and Trench Safety Plan (including calculations) prepared by an Engineer licensed in the State of Washington.

1.5 QUALITY ASSURANCE

A. Contractor's sheeting and shoring plans shall be designed by a Structural Engineer licensed in the State of Washington.

2. PRODUCTS

2.1 TRENCHES

A. Materials used shall be at the Contractor's option.

3. EXECUTION

3.1 SAFETY REQUIREMENTS

A. Shoring shall be placed in accordance with Federal, State and local safety requirements and in accordance with the Contractor’s Shoring, Sheeting and Trench Safety Plan.

3.2 CRIBBING AND SHEETING

A. Unless otherwise noted, the Contractor shall provide all cribbing and sheeting needed to protect the work, adjacent property and improvements, utilities, pavement, and to provide safe working conditions in the trench.

B. Removal of any or all cribbing and sheeting from the trench shall be accomplished in such a manner as to fulfill the above requirements and shall also be accomplished in such a manner as to prevent damage to the work.

C. Damages resulting from improper cribbing or from failure to crib shall be the sole responsibility of the Contractor.

D. Cribbing will not be a pay item and the cost thereof shall be included in the contract price for each of the various items of work included in the project unless otherwise provided.

E. Whether cribbing and sheeting shall be left in place or removed shall be at the option of the Contractor, provided that removal of any and all sheet piling, sheeting or cribbing used in trench or structure excavation shall be accomplished in the manner as to prevent the settlement of the pipes or other work and to prevent increased backfill loading which might overload the pipe or walls of the structure.

F. Should the Engineer order that any sheeting or cribbing be left in place, the Contractor shall not remove the same but will receive payment for the materials left in place on a unit price basis if it is in the Contract or at the market value thereof if there is no such unit price.

3.3 SPECIAL REQUIREMENT FOR FLEXIBLE PIPE

A. Shoring to be removed, or moveable trench shields or boxes, shall be located at least 2-1/2 pipe diameters away from the pipe if the bottom of the shoring, shield or box extends below the top of flexible pipe, unless a satisfactory means of reconsolidating the bedding or side support material disturbed by shoring removal can be demonstrated.

B. Damages resulting from improper shoring or failure to shore shall be the sole responsibility of the Contractor.

* * * END OF SECTION * * *

SECTION 02221

EXCAVATING, BACKFILLING AND COMPACTING FOR STRUCTURES

1. GENERAL

1.1 DESCRIPTION OF WORK

A. This Section includes earthwork and subgrade preparation for structures including, but not limited to, concrete slab, vaults, and wetwell.

B. The Contractor shall provide excavation, removal, stockpiling, disposal and backfilling of whatsoever nature necessary for construction of structures.

C. The Contractor shall provide construction and subsequent removal of shoring and cribs that may be necessary for the protection of existing structures, construction of structures, other excavations and utilities, placement and compaction of backfill.

D. Excavation for manholes and catch basins, and other similar utility structures is specified in Section 02222.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A.	Section 01300:	Submittal Procedures.
B.	Section 02065:	Demolition.
C.	Section 02150:	Shoring.
D.	Section 02222:	Excavation, Backfilling and Compacting of Utilities.
E.	Section 02275:	Sedimentation Control.
F.	Section 02240:	Dewatering.
G.	Section 03485:	Precast Concrete Vaults.

1.3 REFERENCE

A. City of Seattle (COS) Standard Specification Sections referenced in this Specification shall be 2011edition of COS Standard Specifications for Road, Bridge and Municipal Construction, unless otherwise noted.

1.4 SUBMITTALS

A. Procedure: Conform to Specification Section 01300 - Submittal Procedures.

B. Import material gradation and moisture density compaction curve test reports.

C. Native materials gradations and moisture density standards curve test reports.

D. Certification of gradation and compliance with referenced standards, and moisture density standards test reports.

E. Density test results in approved format.

F. At any time the Contractor changes the source and/or stockpile from which materials are obtained, certificates of gradation for these new sources shall also be provided.

G. During construction, the Engineer may elect to have further gradation testing completed on the materials being furnished by the Contractor. This testing will be at the expense of the Owner, however, the Contractor shall provide material samples as may be necessary to complete this testing and these material samples shall be furnished from material available on the job site or from the Contractor's source and/or supplier.

1.5 QUALITY ASSURANCE

A. Construction and material quality standards for this Section shall be as described in the COS Standard Specifications.

B. Referenced Standards:
   1. Testing: ASTM E329.
   2. Classification of Soils: ASTM D2487.
   3. Moisture density standard: ASTM D1557 or AASHTO T-180 method unless otherwise specifically approved.
   4. Moisture Content: ASTM D3017, ASTM D2216.
   5. In-place Density Determination: Sandcone method ASTM D1556; or Nuclear method ASTM D2922.
   6. Classification of Soils ASTM D2487.
   7. Gradation: ASTM C136.

C. Quality control monitoring of subgrade fill shall be performed by certified independent laboratory.

1.6 SITE CONDITIONS

A. A review of previous geotechnical investigations was performed and the findings of the review are presented in a technical memorandum titled, "Review of Geotechnical Reports, North Boeing Field, dated April 21, 2001." This memorandum is provided as Appendix A to Specification Section 03485 – Precast Concrete Vaults. Geotechnical investigation reports referenced in the memorandum are available upon request from the Owner.

2. PRODUCTS

2.1 IMPORTED STRUCTURAL FILL

A. Imported structural fill shall be Bank Run Gravel conforming to COS Standard Specification Section 9-03.16, Mineral Aggregate Chart.

2.2 NATIVE BACKFILL

A. Native material may be used as backfill if the moisture content is near optimum and the silt content is not too high, as determined and approved by the Engineer.

B. Native soil shall be free of organic debris or other deleterious material and shall not contain cobbles or boulders that exceed 5-inch diameter.

C. Free of excess moisture.

D. Processed to uniform moisture and texture necessary to obtain specified density.

3. EXECUTION

3.1 QUALITY CONTROL

A. The Contractor shall conform to the technical provisions of COS Standard Specifications Division 2, Earthwork.

3.2 GENERAL EXCAVATION REQUIREMENTS

A. The Contractor shall exercise care and caution in performing the Work so as not to cause any slide or slip beyond the limits of the structure excavation.

B. Excavation, sloped back sufficiently to prevent sliding of shoring, shall be provided. Design of shoring is the responsibility of the Contractor.

C. Excavations shall extend a sufficient distance from walls and footings to allow for placing and removal of forms, installation of services, and for inspection, except where concrete is specified to be placed directly against excavated surfaces.

3.3 INSPECTION

A. During the course of excavation, the Engineer may stop the work and make bearing tests or test borings, and the Contractor shall give any assistance the Engineer may need in making such tests and shall receive no extra compensation for such stoppages. Materials and labor furnished by the Contractor for such tests will be considered as incidental to the work.

B. When the foundation excavation is completed, the Contractor shall notify the Engineer who will make an inspection and approve the work before any additional work or structure is placed thereon.

C. Contractor shall additionally notify the Engineer on completion of placement of foundation material. The Contractor shall employ an independent testing firm to provide inspection and compaction testing. Inspection and testing reports shall be approved before any additional work or structure is placed thereon.

3.4 STOCKPILING NATIVE MATERIALS FOR REUSE

A. Stockpile excavated materials separately.

3.5 CONCRETE SLAB

A. The subgrade shall be proof-rolled to confirm that subgrade contains no soft or deflecting areas. Proof rolling shall consist of at least three complete (back and forth) passes of a heavy (at least 10 ton) vibratory roller. Vibration shall be used only for granular soils. Areas of excessive yield shall be excavated and backfilled with imported structural fill. If zones of softened or Stratum 2 (soft sandy SILT (ML)) soil are encountered in the subgrade, they shall be replaced with imported structural fill.

B. Additional fill used to increase the subgrade elevation shall meet the requirements for imported structural fill.

3.6 WETWELL

A. Subgrade preparation for wetwell shall be in accordance with Section 03485 - Precast Concrete Vaults.

B. Backfill for the wetwell shall meet the requirements of native backfill or imported structural fill.

3.7 FILL PLACEMENT

A. Imported structural fill shall be placed in layers of not more than 12-inch thickness, at moisture content within three percent (3%) of optimum, and compacted to a minimum density of 95% of the maximum dry density per ASTM D1557.

B. For structural fill below footings, the compacted backfill shall extend outside the perimeter of the footing for a minimum distance equal to the thickness of the fill beneath the bottom of the footing.

3.8 BACKFILLING

A. The Contractor shall provide and place backfill necessary to bring the site to the grades shown on the Drawings or to match surrounding grades.

B. Backfill shall not be placed until the subgrade portions of the structure have been inspected by the Engineer.

C. No backfill material shall be deposited against concrete structures until the concrete has developed a strength of not less than 3,000 pounds per square inch in compression, or until the concrete has been in place for 28 days, whichever occurs first.

D. Backfill material shall be placed in uniform layers and shall be brought up uniformly on all sides of the structure.

E. Backfill material shall be compacted to a minimum density of 95% of the maximum dry density per ASTM D1557.

F. Native soil used as backfill shall be near optimum moisture according to the modified Proctor test method per ASTM D1557. Native soils not meeting optimum moisture content should be moisture conditioned by wetting or drying prior to placement. When soil with moisture content exceeding 3% of optimum is to be used, it shall first be spread in thin lifts or wind rows, aerated, and turned over until it reaches near optimum conditions.

G. Native soil shall be placed in loose lifts not exceeding 8-inch thickness and compacted to 95% of maximum dry density according to the modified Proctor per ASTM D1557.

H. If native soil does not meet the requirements of this specification, imported structural fill shall be used for backfill. Imported structural fill shall be placed in layers of not more than 12-inches thickness, at moisture content within three percent (3%) of optimum, and compacted to a minimum density of 95% of the maximum dry density per ASTM D1557.

I. Mechanical or power tampers may be used in compacting the backfill material; however, no equipment or tamper may be used which by its weight or movement will damage, move or tilt out of alignment any part of the structure above or below the ground surface.

J. Contractor shall be responsible for any such damages and shall make necessary corrections and repairs at his own expense.

K. Unless otherwise specified, backfill around and above pipelines within the excavation line of any structure shall be the same as that specified for structures.

3.9 DENSITY TEST RECORD DOCUMENTATION

A. Location of horizontal and vertical grid and datum.

B. Density and percent of referenced standard computation.

C. Material description and appropriate compaction control standard.

3.10 DENSITY TEST FREQUENCY

A. Backfill zone around structures for each one-foot of backfill height, conduct one test for every 300 square feet.

B. Additional tests as required by the Engineer if tests indicate compaction deficiency.

* * * END OF SECTION * * *

SECTION 02222

EXCAVATING, BACKFILLING AND COMPACTING FOR UTILITIES

1. GENERAL

1.1 DESCRIPTION OF WORK

A. This Section includes earthwork and subgrade preparation for utilities.

B. The Contractor shall provide excavation, removal, stockpiling, disposal and backfilling of whatsoever nature necessary for construction of installation of utilities.

C. The Contractor shall provide construction and subsequent removal of shoring and cribs that may be necessary for the protection of existing structures, excavations for utilities and placement and compaction of backfill.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A.	Section 01300:	Submittal Procedures.
B.	Section 02221:	Excavating, Backfilling and Compacting for Structures.
C.	Section 02240:	Dewatering.
D.	Section 02275:	Sedimentation Control.

1.3 REFERENCE

A. City of Seattle (COS) Standard Specification Sections referenced in this specification shall be 2011edition of COS Standard Specifications for Road, Bridge and Municipal Construction, unless otherwise noted.

1.4 CLASSIFICATION

A. The terms earthwork or excavation include materials excavated or removed regardless of material characteristics.

B. The Contractor shall make his own estimate of the kind and extent of materials, which will be encountered in the excavation.

1.5 SUBMITTALS

A. Procedure: Conform to Specification Section 01300 - Submittal Procedures.

B. Import backfill gradation and moisture density compaction curve test reports.

C. Native backfill materials gradations and moisture density compaction curve test reports.

D. Certification of gradation and compliance with referenced standards and moisture density standards test reports.

E. Density test results in approved format.

F. At any time the Contractor shall change the source and/or stockpile from which materials are obtained, certificates of gradation for these new sources shall also be provided. The Contractor shall make allowances in his unit prices bid for these items to cover expenses incurred in having this certification made and no additional compensation will be allowed.

G. During construction, the Engineer may elect to have further gradation testing completed on the materials being furnished by the Contractor. This testing will be at the expense of the Owner, however, the Contractor shall provide material samples as may be necessary to complete this testing and these material samples shall be furnished from material available on the job site or from the Contractor's source and/or supplier.

1.6 QUALITY ASSURANCE

A. Soils and Backfill: Moisture density standard per COS Standard Specifications Section 2-11.3(2).

B. In-place Density Determination: Sandcone method ASTM D1556 or Nuclear method ASTM D2922.

C. Classification of Soils: ASTM D2487.

D. Quality control monitoring of subgrade backfill materials and construction by certified independent laboratory.

E. COS Standard Specifications.

1.7 SITE CONDITIONS

A. A review of previous geotechnical investigations was performed and the findings of the review are presented in a technical memorandum titled, “Review of Geotechnical Reports, North Boeing Field, dated April 21, 2001.” This memorandum is provided as Appendix A of Section 03485 - Precast Concrete Vaults. Geotechnical investigation reports referenced in the memorandum are available upon request from the Owner.

2. PRODUCTS

2.1 BACKFILL MATERIALS

A. These materials shall be native materials and as described in this section.

2.2 PIPE ZONE BEDDING

A. Pipe bedding material for ductile iron pipe for storm drains shall be Class B, conforming to COS Standard Specifications Section 7-17.3(1)B5 “Bedding for Ductile Iron Pipe”.

B. Pipe bedding material for all HDPE storm drains shall be Class B, conforming to COS Standard Specification Section 7-17.3(1)B3 “Bedding for Flexible Pipe”.

C. The Contractor shall provide the Engineer with a certificate of gradation or sieve analysis from a qualified testing laboratory for bedding material furnished under this contract.

2.3 TRENCH BACKFILL

A. Trench backfill material for all storm drains shall conform to COS Standard Specifications Section 7-17.3(3) “Backfilling Trenches” and the Drawings.

3. EXECUTION

3.1 TRENCHING

A. Trench excavation for all storm drains shall conform to COS Standard Specifications Section 7-17.3(1)A “Trench Excavation” and the Drawings.

3.2 PIPE BEDDING

A. Placement of bedding material for all storm drains shall conform to COS Standard Specifications Section 7-17.3(1)B “Pipe Bedding”.

3.3 BACKFILLING

A. Trench backfill material for all storm drains and sanitary sewers shall conform to COS Standard Specifications Section 7-17.3(3) “Backfilling Trenches” and the Drawings.

3.4 BACKFILL COMPACTION REQUIREMENTS

A. Compaction of backfill for storm drains shall conform to COS Standard Specifications Section 7-17.3(3)B “Compaction of Trench Backfill”.

3.5 MECHANICAL COMPACTION

A. Method of compaction shall be at the Contractor's option provided the specified compaction requirements are met.

B. The Contractor shall provide the proper size and type of compaction equipment and select the proper method of utilizing said equipment to attain the required compaction density.

C. In place compaction tests may be made. The Contractor shall remove and recompact material that does not meet specified requirements.

* * * END OF SECTION * * *

SECTION 02240

DEWATERING

1. GENERAL

1.1 DESCRIPTION OF WORK

A. This section includes dewatering excavations of any kind and location, including but not limited to groundwater, surface water, seepage, and precipitation.

B. The Section also specifies the definition, responsibilities and execution for temporary dewatering for excavations extending below the water table. The Contractor shall review and become thoroughly familiar with the groundwater conditions presented in the geotechnical technical memorandum titled, "Review of Geotechnical Reports, North Boeing Field, dated April 21, 2001." The technical memorandum is provided as Appendix A of Section 03485 - Precast Concrete Vaults. In addition, the Contractor may request of the Owner additional reports from previous geotechnical investigations performed at the site or adjacent to the site.

1.2 SCOPE

A. The Contractor shall be fully responsible for acquainting itself with the available information, existing site conditions, and relevant regulatory requirements prior to commencing temporary dewatering activities. Dewatering is a time-sensitive component of the project and should be scheduled to facilitate excavation and construction of utilities and structure excavations.

B. The Contractor shall include all costs in its Bid to provide the dewatering sufficient to control groundwater to maintain dry excavations, prevent sloughing, softening of the bottom of any excavation, and prevent formation of "quick" conditions "boils" or "heave" during excavation.

C. The Contractor shall design, install, maintain and operate temporary dewatering systems that will prevent water from entering, or promptly remove all water entering, all trenches and excavations from the time that excavation begins until all backfill has been completed for that excavation or pipe-laying operations have been completed for that trench. Where water is encountered in the trench, it shall be removed during pipe-laying operations and the trenches so maintained until ends of pipe are sealed and provisions are made to prevent floating of the pipe. Trench water or other deleterious materials shall not be allowed to enter the pipe at any time.

D. Provisions shall be made to remove any perched groundwater entering excavations. The Contractor shall assure that the dewatering systems operate continuously during each stage or phase of excavation and backfill. The

Contractor shall ensure that the operation of any temporary dewatering system does not result in excessive drawdowns, undesirable hydraulic gradients, the removal of fines, or induce settlement of ground, buildings or utilities. The Contractor shall comply with all worker safety laws and regulations as described in these Specifications.

E. Clean groundwater encountered during excavation operations shall be collected by the Contractor. Contaminated groundwater is not anticipated to be encountered, but if it is encountered, the Contractor shall notify the Owner immediately. If negotiated with the Owner, the contaminated water shall be treated and disposed of in a legal manner in accordance with applicable disposal regulations and water quality criteria.

1.3 RELATED WORK SPECIFIED ELSEWHERE

A. Section 02150: Shoring.

B. Section 02221: Excavating, Backfilling and Compacting for Structures.

C. Section 02222: Excavating, Backfilling and Compacting for Utilities.

D. Section 02584: Manholes.

E. Section 03485: Precast Concrete Vaults.

1.4 REFERENCES

A. City of Seattle (COS) Standard Specification Sections referenced in this specification shall be the 2011edition of COS Standard Specifications for Road, Bridge and Municipal Construction, unless otherwise noted.

1.5 QUALITY CONTROL

A. It shall be the sole responsibility of the Contractor to control the rate and effect of the dewatering efforts to avoid objectionable settlement and subsidence. The Contractor shall comply with Federal, State and local codes and ordinances regarding the disposal of water pumped from dewatering operations.

B. Proposed discharge points shall be approved by the Owner prior to implementation of dewatering. The Contractor shall be responsible for taking all reasonable precautions necessary to ensure continuous, successful operation of the system.

1.6 RISK OF SETTLEMENT OF ADJACENT STRUCTURES

A. The Contractor shall design all dewatering system components such that water table drawdown outside the immediate trench and/or excavation area does not result in settlement of existing structures, including buildings, utilities, transformers, curbs, walkways, etc. Prior to dewatering, the Contractor shall conduct a survey of the foundations of all significant structures (i.e., buildings) within 100 feet of any dewatering wells or sumps. The survey shall include documentation (including photographs) identifying all cracks, fractures or settlements existing prior to beginning dewatering activities. The Contractor shall bear the sole responsibility for any and all costs to adjacent structures associated with settlement resulting from operation of the temporary dewatering systems.

1.7 SUBMITTALS

A. Procedure: Conform to Specification Section 01300 - Submittal Procedures.

B. Prior to starting implementation of dewatering activities, the Contractor shall prepare a Dewatering Plan, in accordance with COS Standard Specification Section 2-08, Dewatering, Section 8-01.3(2)D, Temporary Discharge Plan, and WSDOT Standard Specifications Section 8-01.3(1)C, that includes details and construction sequences that address the handling and disposal of turbid water. Submit a Dewatering Plan to the Engineer for review 10 days prior to commencement of any construction activity, including erosion control. The Dewatering Plan shall be prepared by a Professional Engineer or Hydrogeologist who is licensed to practice in the State of Washington, and who has a minimum of five (5) years of experience in the design of dewatering systems for similar projects. The Contractor shall be responsible for preparing, submitting, and obtaining approval of the Dewatering Plan from the appropriate permitting agencies. No work shall commence without the permits and no groundwater withdrawals are to be allowed, unless the Contractor obtains the appropriate permits.

C. Any changes to the proposed system shall be submitted to the Engineer for review prior to implementation. The Engineer’s review does not constitute approval. The adequacy and performance of the dewatering system is the sole responsibility of the Contractor.

D. The dewatering system shall be designed using accepted and professional methods of hydrogeologic analysis and groundwater engineering design.

E. In addition to the dewatering system design, the submittal should include a contingency plan for storm events or other conditions (including failure of the dewatering system) that could raise groundwater levels and overwhelm the capacity of the dewatering system pumps or discharge facilities.

F. The Engineer’s review of the Dewatering Plan shall not constitute approval nor relieve the Contractor from full responsibility for errors therein nor from the entire responsibility for complete and adequate groundwater level control and volume removal in the excavated areas to the extent specified herein. The Contractor shall be solely responsible for control of the groundwater levels and hydrostatic pressures to the depths herein specified and for avoiding settlement outside the excavation as herein specified. The Contractor shall bear sole responsibility for proper design, installation, operation, maintenance and any failure of any component of the temporary dewatering system for the duration of the Contract.

1.8 SUBMITTALS: FINAL DEWATERING REPORT

A. Within 30 days after completion of the dewatering operations, the Contractor shall submit water quality sampling and analysis results.

2. PRODUCTS

2.1 GENERAL

A. Materials for dewatering system construction shall conform to the industry standard for construction dewatering for high capacity requirements necessary to obtain a dry trench condition for the installation of piping, manholes, catch basins, and wetwells and the construction of foundations.

B. Descriptions and specifications of proposed equipment and materials shall be provided in the Dewatering Plan.

2.2 PUMPS AND PIPING

A. The Contractor shall provide and size appropriately all pumps and piping necessary to convey and remove groundwater to the designated point of discharge, via water treatment facilities as required.

B. The piping shall be designed to minimize head loss and turbulent flow, and shall be protected from all vehicular traffic or other potential damage as appropriate.

2.3 FLOW METERS

A. The Contractor shall provide, install and maintain flow meters of sufficient size to accurately measure the instantaneous flow rate and totalized flow volume of water pumped from the dewatering system(s).

B. Calibration documentation for all flow meters shall be included in the Dewatering Plan.

2.4 STANDBY EQUIPMENT

A. The Contractor shall maintain on-site, at a minimum level of 20 percent, additional dewatering system components, including valves, flow meters, pumps and piping, and other system hardware to ensure that immediate repair or modification of any part of the system can be made.

2.5 STANDBY POWER

A. The Contractor shall have on-site secondary electrical generating capacity or other source of power, in case the primary power source is lost. The standby power source shall meet the requirements of Division 1 of these specifications.

B. Power system and standby power services for the temporary dewatering system(s) shall be independent from power sources used or required for the project. The Contractor shall use this electric service solely to power the temporary dewatering system, separate from all other power needs.

C. If the power is provided by engine generators the system shall meet all noise requirements and regulations.

3. 3. EXECUTION

3.1 INSTALLATION AND APPLICATION

A. The dewatering systems shall be designed, installed and operated in a manner so that the soil below existing structures and the proposed utilities and structures is not disturbed and softened.

B. The Contractor shall meet the requirements of WAC 173-160 for all well construction, development and decommissioning. The Contractor shall design all dewatering system components such that formation materials (sand and silt) do not move during pumping.

C. Notification: The Contractor shall promptly notify the Engineer and/or the Owner of any groundwater that the Contractor believes may be chemically contaminated.

3.2 OPERATION REQUIREMENTS

A. The Contractor shall be or shall employ the services of a specialist subcontractor who is generally recognized as experienced and knowledgeable in the field of dewatering system installation, operation and maintenance. The Contractor shall employ the services of a licensed water well driller per WAC 173-162 for all well drilling, installation, construction, development and testing. The dewatering system shall be operated at all times by workers who are competent and trained in all aspects of the system operation, maintenance and monitoring, and who have had at least 40 hours current valid health and safety training per Occupational Safety and Health Administration (OSHA).

B. The Contractor shall control surface runoff so as to prevent entry or collection of water in excavations or in other isolated areas of the site.

3.3 OPERATIONAL MONITORING

A. The Contractor shall provide continuous monitoring of the dewatering system, by experienced personnel present on site or available on call.

B. The Contractor shall bear full responsibility for all damages to work in the excavation area and for damages to any other area or structures caused by the Contractor's failure to maintain and operate the system properly.

3.4 SYSTEM INSTALLATION, DEVELOPMENT AND TESTING

A. The Contractor shall bear full responsibility for acquiring a water supply with which to install any dewatering system components necessary to achieve proper completion of all work performed under this Contract (i.e., drilling and/or jetting). Mud-rotary drilling is not permitted as a method for well installation. No additives other than clean water shall be allowed during well drilling.

B. Well discharge shall meet all water quality regulations at all times.

3.5 DEWATERING SYSTEM PROTECTION

A. The Contractor shall bear full responsibility for taking all reasonable precautions necessary to ensure continuous, successful operation of the temporary dewatering systems. This includes establishing and/or maintaining adequate marking of all well, pump and pipeline locations and protecting the temporary dewatering system components against damage or theft.

3.6 FORMATION PROTECTION

A. The Contractor shall design, construct, operate and maintain the dewatering systems such that foundation soils, natural or engineered, does not experience fines removal upon pumping.

B. The Contractor shall provide all of the equipment to test for water quality including sand monitoring, if necessary.

3.7 SYSTEM REMOVAL

A. As work is completed in each area of the project, the Contractor may decommission and remove dewatering system elements. The Contractor shall assume ownership and responsibility for the disposal of dewatering pumps, pipes and other assorted system hardware. The Contractor shall employ the services of a licensed water well driller per WAC 173-162 for well decommissioning and removal, which shall be accomplished in accordance with WAC 173-160. Notify the Engineer before removing system elements.

3.8 WATER TREATMENT

A. The Contractor may be required to provide and maintain a water treatment system that is capable of treating and discharging water to a storm sewer system as approved by the Owner and/or AHJ, in accordance with the discharge permit. The water treatment facilities are not extra work and costs shall be included in the pay item that covers dewatering costs.

B. The water treatment system shall have the treatment and storage capacity to manage water from dewatering operations without causing construction delays. Contractor shall keep on hand, or have immediate access to, spare components to prevent breakdowns of water treatment. The materials and equipment used for the water treatment system shall be suitable for the work and be maintained in good condition.

C. The Contractor shall provide and maintain at all times a flow meter to record total water volumes discharged to storm drain or sewer systems. The flow meter shall record instantaneous and total flow. The Contractor shall choose the type and size of equipment and components needed to accomplish the functions designated.

D. The Contractor shall provide all materials, labor, traffic control, permits and all other work for connecting to the system. The Contractor shall consider limitations, such as flow capacity of storm, and sewer systems that are proposed to receive the treated water.

3.9 DEWATERING DISCHARGE

A. All water removed by the dewatering system(s) (and treated as required by regulatory requirements) shall be discharged to appropriate discharge points coordinated with the Owner and Engineer. Discharges to storm drains that flow to an outfall shall conform to all requirements of the National Pollution Discharge Elimination System (NPDES) and State General Permit for stormwater discharges associated with Construction Activities. Water shall be discharged at one or more designated points, at rates not to exceed the local flow capacity of the storm drain or sanitary sewer system.

B. Other necessary permits required for discharge, shall be identified by the Contractor and obtained from regulatory agencies with appropriate jurisdiction.

3.10 DISCHARGE CRITERIA

A. Dewatered water shall be contained and discharged to appropriate stormwater outlets, as directed by the Engineer. Contained water shall meet all applicable discharge criteria prior to discharge.

* * * END OF SECTION * * *

SECTION 02275

SEDIMENTATION CONTROL

1. GENERAL

1.1 DESCRIPTION OF WORK

A. This section includes materials and methods for controlling erosion and sedimentation during the Work.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Section 01300: Submittal Procedures.

B. Section 02221: Excavating, Backfilling and Compacting for Structures

C. Section 02222: Excavating, Backfilling and Compacting for Utilities

1.3 REFERENCE

A. City of Seattle (COS) Standard Specification Sections referenced in this specification shall be the 2011edition of the COS Standard Specifications for Road, Bridge and Municipal Construction, unless otherwise noted.

1.4 SUBMITTALS

A. Procedure: Conform to Specification Section 01300 - Submittal Procedures.

B. The Contractor shall submit a Construction Stormwater Control Plan (CSCP) to the Engineer at least 10 days prior to construction activities.

C. The Contractor shall submit weekly updates of the CSCP to the Engineer. The updates shall describe changes to the previous CSCP revision including, but not limited to:
1. Major changes to work methodology.
2. Major changes to best management practices (BMPs) used as part of the Work.
3. An explanation of why changes have been made.
4. Comments that may be received from the Engineer.

D. Prior to shipping material to the site, the Contractor shall submit to the Engineer samples of silt fence material and straw wattle proposed for the Work.

E. Prior to shipping material to the site, the Contractor shall submit to the Engineer product specifications, installation recommendations and proposed construction methods for the materials, equipment and activities listed below:

1. Silt fences.
2. Sandbags.
3. Straw wattles.
4. Clear plastic cover.
5. Erosion control mat.
6. Temporary sediment tank.
7. Dust palliatives.
8. Street sweepers.
9. Street sweeping method.
10. Temporary inlet protection.

F. When no sedimentation control system is shown on the Drawings, the Contractor shall provide and design a system to prevent siltation of adjacent property or streams.

1.5 TEMPORARY EROSION AND SEDIMENTATION CONTROL PLANS

A. The Contractor shall conform to the temporary erosion and sedimentation control plan shown on the Drawings and CSCP.

B. The Contractor’s erosion and sedimentation control program shall comply with the requirements of the City of Seattle (COS), 2009 Stormwater Manual.

1.6 QUALITY ASSURANCE AND QUALITY CONTROL

A. Conform to COS Standard Specifications Section 8-01, Construction Stormwater Pollution Prevention.

B. Conform to COS Standard Specifications Section 9-14, Erosion and Landscape Materials.

C. Conform to Federal, State and local regulatory requirements.

D. When sedimentation control systems are shown on the Drawings, they are intended to be minimum requirements to meet anticipated site conditions. Additional measures may be required to meet the provisions of the Contract Documents.

E. The Contractor shall be responsible for Construction Quality Control (CQC).

F. The Engineer shall be responsible for Construction Quality Assurance (CQA). The Engineer shall be responsible for observing and documenting periodic verification, checking, or testing for confirming that the quality of the erosion and sedimentation control is in accordance with the Contract Documents.

G. Unless otherwise specified, the Contractor shall complete CQC inspection, sampling, testing or any other action, as considered necessary by the Contractor to ensure that the Work has been completed in accordance with the Contract Documents. Notwithstanding the results of the Contractor’s CQC program, compliance of the Work with the Contract Documents shall be defined by the results of the Engineer’s CQA program.

H. Any Work that does not satisfy the requirements of the Contract Documents shall be made good in accordance with the requirements of the Contract Documents or as directed by the Engineer at the sole expense of the Contractor.

1.7 CERTIFIED EROSION AND SEDIMENTATION CONTROL LEAD

A. The Contractor shall engage and pay for the services of qualified staff or a qualified subcontractor to perform CQC for monitoring and documenting the quality of the erosion and sedimentation control in accordance with the Contract Documents.

B. The Contractor shall name the employee designated to act as the Certified Erosion and Sediment Control Lead (CESCL) for the project. All such personnel shall be certified by WSDOT/AGC as having completed the Construction Site Erosion and Sediment Control Certification Program. Such certification shall remain in effect throughout the Contract term.

C. The duties of the CESCL shall include, but are not limited to:

1. Inspecting temporary erosion and spill control BMPs for proper location, installation, maintenance, and repair. Inspections shall be made weekly, and after each precipitation event, including those that occur during weekends and after working hours. Inspection form that is included in the CSCP prepared for the Project shall be completed for each inspection and shall be included in the Temporary Erosion and Spill Control file. The inspection report shall include, but not be limited to:
   a. When BMPs are installed, removed or changed;
   b. Repairs needed or made;
   c. Observations of BMP effectiveness and proper placement; and
   d. Recommendations for improving performance of BMPs.
2. Prepare and maintain a Temporary Erosion and Spill Control file on site that includes but is not limited to:
   a. Temporary Erosion and Spill Control Inspection Reports;
   b. CSCP;
   c. Spill Prevention, Control, and Countermeasures (SPCC) Plan;
   d. Project permits, including but not limited to grading permit; and
   e. Manufacturer instructions for products used for TESC.

1.8 SCHEDULE

A. Erosion and sediment control measures shall be installed prior to earth-disturbing activity.

B. Sediment facilities shall be maintained in a satisfactory condition until such time that construction is completed and potential for onsite erosion has passed.

C. The implementation, maintenance, replacement and additions to erosion/ sedimentation control systems shall be the responsibility of the Contractor.

2. PRODUCTS

2.1 GENERAL

A. Products shall conform to COS Standard Specifications Section 9-14, Erosion and Landscape Materials, unless otherwise specified or approved by the Engineer.

2.2 SILT FENCE

A. Silt fence fabric shall conform to COS Standard Specifications Section 9-37.2, Table 6, Geotextile for temporary silt fence. Geotextile shall be supported between posts with wire or polymeric mesh.

B. The fabric shall be inert to biological degradation and shall be resistant to alkalies and acids found in soils. The base plastic shall contain stabilizers and inhibitors to make the fabric resistant to ultraviolet radiation.

C. Posts for the silt fence shall conform to COS Standard Specifications Section 8-01.3(10), Temporary Sediment Controls.

2.3 STRAW WATTLES

A. Straw wattles shall conform to COS Standard Specifications Section 9-14.16, Wattles.

2.4 CLEAR PLASTIC COVERING

A. Clear plastic covering for protection of slopes and cuts shall conform to Washington State Department of Transportation (WSDOT) Standard Specification Section 9-14.5(3), Clear Plastic Covering.

2.5 TEMPORARY SEED MIX

A. Temporary seed mix shall conform to COS Standard Specifications Section 9-14.2(2), Seed Mix #1 (Erosion Mix).

2.6 TOPSOIL

A. Topsoil shall conform to the requirements of COS Standard Specification Section 8-02.3(2)B, Topsoil Type A (Imported).

2.7 MULCH

A. Mulch shall conform to COS Standard Specifications Section 9-14.4(1), Straw Mulch.

2.8 WATER

A. The Contractor shall use water for the control of dust during construction. The Contractor shall import suitable water from offsite at no additional cost to the Owner.

2.9 STREET SWEEPER

A. Street sweeper shall be in accordance with the CSCP.

B. Street sweeper shall be a self-propelled vehicle outfitted with rotating brushes, water spray and a filtered vacuum system to collect sediment, dust, and debris from paved road surfaces.

C. Street sweeper shall store street sweepings internally.

2.10 DUST PALLIATIVE

A. Dust palliative shall consist of a biodegradable material specifically sold as a dust suppressant and approved by the Engineer.

B. Dust palliative shall be in accordance with the CSCP.

2.11 TEMPORARY INLET PROTECTION

A. Temporary inlet protection shall be in accordance with the CSCP and the Drawings.

B. Geotextile for inlet protection shall conform to Table 2, Geotextile for Underground drainage filtration properties of COS Standard Specification Section 9-37.2, Geotextile Properties.

3. EXECUTION

3.1 GENERAL REQUIREMENTS

A. Nothing within this Specification or the Drawings shall relieve the Contractor from complying with other Contract requirements.

B. The Work defined by this Specification shall include, but not be limited to:
   1. The furnishing and delivery of all required materials.
   2. The installation and maintenance of all temporary and permanent erosion and sediment control measures as shown on the Plans.
   3. Supply and operation of street sweepers, water carts, and other material or equipment for the control of dust.
   4. The provision of temporary piping, pumping, transport, and temporary sedimentation tanks, as required during the course of the Work to control surface water run-on and surface water run-off; to ensure that surface waters entering the construction areas are directed to the appropriate detention or containment facilities.

C. If sediment laden water leaves the work area, the Engineer will consider the existing erosion control measures to be inadequate. The Contractor shall be required to complete additional maintenance and/or construct additional erosion and sediment control facilities.

D. The Contractor shall not allow the area of work to exceed his ability to adequately prevent sediment from leaving the work area.

E. When, in the opinion of the Engineer, temporary erosion and sedimentation control devices are no longer needed, the Contractor shall remove them and finish the areas in accordance with the Contract Documents.

F. The Contractor shall brief all employees working on the site on the CSCP. The briefing shall include, but not be limited to:
   1. Temporary erosion and sedimentation control system maintenance.
   2. Spill prevention practices, and spill response and cleanup procedures.
   3. The importance of erosion and sediment control BMPs, including details of the BMPs to be incorporated in the work.

3.2 EROSION CONTROL

A. Erosion control provisions shall meet or exceed the requirements of the local agency having jurisdiction.

B. When provisions are specified and shown on the Drawings, they are the minimum requirements.

C. The Contractor shall not permit sediment-laden waters to enter drainage facilities.

D. As construction progresses and seasonal conditions dictate, more siltation control facilities may be required. It shall be the responsibility of the Contractor to address new conditions that may be created and to provide additional facilities over and above minimum requirements as may be required.

3.3 SILT FENCES

A. Silt fences shall be installed and maintained in accordance with the Drawings, COS Standard Specifications Section 8-01.3(10), Temporary Sediment Controls and WSDOT Standard Plans I-30.15-00.

3.4 STRAW WATTLES

A. Straw wattles shall be installed and maintained in accordance with COS Standard Specifications Section 8-01.3(13), Compost Socks, Compost Berms and Straw Wattles.

3.5 PLACING CLEAR PLASTIC COVERING

A. Plastic covering shall be installed and maintained in accordance with COS Standard Specifications Section 8-01.3(8), Plastic Covering.

B. Clear plastic covering shall be installed on stockpiles and as directed by the Engineer.

C. Clear plastic covering shall be installed immediately after completion of the application of temporary seeding.

D. The Contractor shall be responsible to immediately repair all damaged areas.

3.6 TEMPORARY SEEDING

A. Temporary seeding shall conform to COS Standard Specifications Sections 8-01.3(5)D, Seeding; 8-01.3(5)E, Time for Application of Seed, Fertilizer, and Mulch; and 8-01.3(5)F, Establishment Period and Maintenance.

3.7 MULCHING

A. Mulching shall conform to COS Standard Specifications Sections 8-01.3(6)A, General and 8-01.3(6)B, Straw Mulch.

3.8 DUST CONTROL

A. Dust control shall be in accordance with the CSCP and the Drawings.

B. If, in the opinion of the Engineer, the dust pollution at the site is excessive due to the Contractor’s failure to control dust during Work, the Work shall be stopped on grounds that the Contractor is not performing work to required quality standards. Any such work stoppage shall be at the Contractor’s sole expense.

C. The period of soil exposure shall be minimized through the use of plastic covering temporary seeding, and mulching.

D. Water shall be applied, as needed, for the control of dust to all roads trafficked as part of the Work. The Contractor shall apply water by means of tank trucks equipped with spray bars. Spray controls shall ensure that the water flows evenly and in amounts adequate for the control of dust.

E. The Engineer may direct that the Contractor apply water at night or early in the morning to reduce evaporation losses.

F. If necessary, spray exposed soil areas with dust palliative.

G. Vehicular speeds shall not exceed 10 miles per hour through construction zones in order to control dust and to promote safety within the work area.

3.9 STREET SWEEPING OPERATIONS

A. Street sweeping operations shall be in accordance with the CSCP.

B. The Contractor shall provide street sweeping on paved areas and roads used by Contractor's equipment for the duration of the Contract.

C. Street sweeping shall be performed at the direction of the Owner and/or Engineer. Street sweeping shall begin before 12:00 p.m. on the day following the Owner's and/or Engineer's request, and be completed before the end of that day.

D. Collected street sweepings shall be disposed of at an approved off-site disposal facility.

3.10 TEMPORARY INLET PROTECTION

A. Temporary inlet protection shall be in accordance with the Drawings and the CSCP.

3.11 EXISTING DRAINAGE FACILITIES

A. Should a storm drain, manhole or catch basin become blocked or have its capacity restricted due to discharge siltation from the Contractor's operations, the Contractor shall make arrangements with the jurisdictional agency for the cleaning of the facility at no additional cost to the Owner.

B. New drainage facilities that become blocked or silted shall be cleaned by the Contractor at no additional cost to the Owner.

3.12 TEMPORARY SEDIMENTATION TANKS

A. Temporary sedimentation tanks shall be in accordance with the CSCP.

B. All pumps and temporary storage tanks used as part of the temporary stormwater control system shall be provided by the Contractor and shall be adequately designed, maintained and operated during and following storm events to prevent off-site migration of stormwater or materials from within the work area.

3.13 DRAINAGE DIVERSION

A. The Contractor shall divert the surface runoff water around the site as may be required.

B. Surface drainage shall be restored to conditions existing prior to construction unless otherwise shown on the Drawings or as approved by the Engineer.

3.14 EQUIPMENT WASHING

A. Equipment washing, including truck washing, shall not result in the discharge of water to drainage-ways. Truck wash water shall be appropriately disposed of by hauling to an approved discharge facility.

B. Equipment washing detergent wash water shall be discharged to the sanitary sewer system, with approval from the receiving utility.

C. Cleaning solvents shall be used only where drips and spills can be captured and properly disposed.

D. Concrete wash water shall be disposed of in an area where the wash water does not runoff before the concrete residue can harden. The concrete residue shall be disposed of at an approved offsite disposal facility.

3.15 MAINTENANCE

A. The Contractor shall maintain, clean and remove sediment and debris from permanent surface water facilities, including catch basins, manholes, vaults, wet wells and pipes within the work area no less than once per month during the Contract duration.

B. The Contractor shall maintain, clean and remove sediment from all temporary erosion and sedimentation control structures no less than once per month.

C. The Contractor shall repair existing erosion and sediment control features that are within the work area and are to form part of either the temporary or permanent erosion controls for the Work.

D. The paved roads shall be maintained and any repairs needed shall be at the expense of the Contractor.

* * * END OF SECTION * * *

SECTION 02511

AGGREGATE BASE

1. GENERAL

1.1 DESCRIPTION OF WORK

A. The extent and location of the aggregate work is indicated on the Drawings. The work includes the requirements for producing, transporting, placing, shaping, and compacting courses of one or more materials in conformance with these Specifications and the dimensions and sections indicated on the Drawings or within the lines and grades established by the Engineer.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Section 02513: Hot Mix Asphalt.

1.3 REFERENCE

A. City of Seattle (COS) Standard Specification Sections referenced in this specification shall be the 2011edition of the COS Standard Specifications for Road, Bridge and Municipal Construction, unless otherwise noted.

1.4 SUBMITTALS

A. Procedure: Conform to Specification Section 01300 - Submittal Procedures.

B. Certification of gradation and compliance with referenced standards, and moisture density standards test reports.

C. Density test results in approved format.

D. Recycled content percentage of concrete in aggregate base.

1.5 QUALITY ASSURANCE

A. Quality control monitoring of aggregate base materials and construction by certified independent laboratory supplied by the Contractor. Testing shall be accomplished on the materials listed in the "Aggregates" paragraph of this section, and at the stated frequency.

2. PRODUCTS

2.1 AGGREGATES

A. Crushed Surfacing: COS Section 9-03.9(3)

B. Maintenance Rock: COS Section 9-03.9(4)

C. Aggregate for Gravel Base: COS Section 9-03.10

D. Mineral Aggregate Type 2: COS Section 9-03.16

3. EXECUTION

3.1 EQUIPMENT

A. Equipment necessary for the installation of aggregate base top course crushed rock surfacing shall conform to the requirements of the COS Standard Specifications.

B. Grading machines or trimmers shall be equipped with a spirit level or other type slope indicator which shall continuously indicate the average, transverse slope of the screed. Bubble or indicator movement shall be no less than 1/8-inch for each 0.1% change in transverse slope.

3.2 PLACEMENT OF CRUSHED SURFACING

A. Equipment necessary for the satisfactory performance of this construction shall be on the project and approved by the Engineer prior to beginning work. If central mix plant methods are used, the central mixing plant shall comply with the applicable portions of the COS Standard Specifications.

B. Subgrades shall be prepared as specified in the Contract Documents and approved by the Engineer before placing surfacing materials.

C. After each layer of material is placed, the material shall be mixed by motor graders or other approved equipment until the mixture is uniform throughout. Water shall be added in an amount required or as directed by the Engineer to facilitate mixing and compacting.

D. Each layer of surfacing material shall be spread by means of approved spreading equipment. Such equipment may be one of the following: bottom-dump hauling equipment with transverse spreading facilities; self-propelled spreading and leveling machines; spreader boxes equipped with wheels or so constructed to preclude any damage to the subgrade or underlying courses. Spreading on small areas of less than 2,000 square yards or on areas irregular in shape may be accomplished by other means as approved by the Engineer.

1. The depth of any course of material shall not exceed 6 inches.

E. Immediately following spreading and shaping, each layer of surfacing shall be compacted to at least 95% of the standard density determined by the compaction control test for granular materials before the next succeeding layer of surfacing or pavement is placed thereon. When the thickness of surfacing is less than 0.15 feet, density testing may not be required and the Engineer will determine the number of coverages required for the particular compaction equipment available.

F. Vibratory compactors or rollers shall be adequate in design and number to provide compaction and obtain the specified density for each layer while still moist. A mist spray of water shall be applied as needed to replace moisture lost by evaporation. The completed layer shall have a smooth, tight, uniform surface true to the line and grade to match existing grades and as approved by the Engineer.
   1. Variations in the surface of the top course shall be a maximum of 1/4-inch in 10 feet. Surface elevation shall be within 0.05 feet of design grade. Variations greater than the allowable shall be shaved off or filled in and that area recompacted.
   2. When directed by the Engineer, crushed surfacing top course shall be used for keystone to key the top surface of ballast, gravel base, crushed surfacing base course or any other surfacing course which requires keying. The keystone shall be spread evenly on top of the surfacing course requiring it, by means of approved spreading equipment. The surface shall be watered and, if necessary, bladed lightly until the keystone is worked into the interstices of the surfacing course without excessive displacement and shall be compacted. The operations of adding keystone, wetting, blading, and compacting shall be continued until the course has become thoroughly keyed and compacted.

G. The surface of each layer of surfacing material shall be maintained reasonably true to line and grade by blading, watering, and rolling until placing the next succeeding course. The first course of surfacing material shall be placed on all available subgrade before placing the succeeding course unless otherwise authorized by the Engineer. Should irregularities develop in any surface during or after compaction, they shall be remedied by loosening the surface and correcting the defects after which the entire area, including the surrounding surface, shall be thoroughly recompacted. In the event additional materials are necessary to make the repairs they shall be provided at no additional cost to the Owner.

H. Hauling equipment shall be routed over the roadway in such a manner as to be most effective in the compacting of the surfacing. Hauling over any of the surfacing in process of construction will not be permitted when, in the opinion of the Engineer, the effect will be detrimental.

* * * END OF SECTION * * *

SECTION 02513

HOT MIX ASPHALT

1. GENERAL

1.1 DESCRIPTION OF WORK

A. The extent of the hot mix asphalt pavement work shall be defined by the existing asphalt pavement removed, as required to perform the Work. The work includes, but is not limited to, the requirements for producing, transporting, placing, shaping, compacting, and placing pavement on top of one or more courses of materials in conformance with these Specifications and the dimensions and sections indicated on the Drawings or within the lines and grades established by the Engineer.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Section 02511: Aggregate Base.

1.3 REFERENCE

A. City of Seattle (COS) Standard Specification Sections referenced in this specification shall be the 2011edition of the COS Standard Specifications for Road, Bridge and Municipal Construction, unless otherwise noted.

1.4 SUBMITTALS

A. Procedure: Conform to Specification Section 01300 - Submittal Procedures.

B. Submittals as required by COS Section 5-04.3(6)C.

C. Products and mix proportions to be provided for Hot Mix Asphalt.

D. Liquid and emulsified asphalt products to be provided for Prime and Tack Coats.

E. Products to be provided for Joint Sealing.

F. Submit test reports of gradation and source for asphalt concrete aggregate and blending sand courses.

G. Submit manufacturer's certificates of compliance that pavement and paint marking materials supplied are in accordance with these Specifications.

H. Submit recycled content percentages of asphalt if found.

1.5 QUALITY ASSURANCE

A. Construction standards and quality controls for this Section shall be as described in the COS Standard Specifications.

B. Quality control monitoring of asphalt concrete materials and construction by certified independent laboratory. Testing shall be accomplished on the materials listed in the “Submittals” paragraph of this section, and at the stated frequency.

2. PRODUCTS

2.1 AGGREGATES

A. Aggregates for hot mix asphalt shall conform with the requirements of COS Section 9-03.8.

2.2 BITUMINOUS MATERIALS

A. Materials shall meet the requirements of COS Section 5-04, Hot Mix Asphalt (HMA) Pavement.
   1. Prime coat shall be liquid asphalt CRS-2 in accordance with COS Sections 5-02.3(3) and 5-04.3(4)C2.
   2. Tack coat shall be emulsified asphalt CSS-1, CSS-1h, or STE-1 in accordance with COS Section 5-04.3(4)B4a.
   3. Asphalt for HMA shall be Viscosity Grade PG 64-22 paving asphalt.
   4. Hot Mixed Asphalt Concrete shall be HMA (Class 1”).

2.3 PROPORTIONS OF MATERIALS

A. The materials of which asphalt concrete is composed shall be of such sizes, gradings, and quantities that, when proportioned and mixed together, they produce a well graded mixture within the requirements of COS Standard Specifications.

B. The actual proportions of the several components to be used in the production of the asphalt concrete mixture shall be as determined by the Contractor, and approved by the Engineer, to provide a pavement having surface texture, air flow, and stabilometer and cohesionmeter values satisfactory to the Engineer.

2.4 PAVEMENT MARKINGS

A. Pavement markings shall conform to COS Section 8-22 and Section 9-29.

B. Pavement markings shall be as required to replace, in-kind, existing pavement markings affected by the Work.

C. Paint for pavement markings shall contain reflective glass beads.

3. EXECUTION

3.1 JOINT SEALER

A. Joint sealer shall be applied to the edges of new paving joints, vaults, mat foundations, manholes, and wetwell.

3.2 ASPHALT CONCRETE

A. Asphalt concrete shall be mixed, handled, batched, hauled, placed, rolled, and compacted in accordance with the applicable portions of COS Section 5-04. The material shall be placed to the dimensions and grades as indicated on the Drawings or as directed by the Engineer. Variations in the surface shall be a maximum of ¼-inch in 10 feet. Surface elevation shall be within 0.05 feet of design grade.

3.3 PAVEMENT MARKINGS

A. The Contractor shall replace pavement markings removed or destroyed due to the construction of this project.

B. Paint for pavement markings shall be transported, stored, mixed, and applied in accordance with the manufacturer's published instructions.

C. Clean surface, including removal of old markings, in accordance with manufacturers published instructions, as approved by the Engineer.

D. Preliminary layout for pavement markings shall be approved by the Engineer, prior to application of paint.

E. Pavement markings shall be protected from damage during curing. Contractor shall refurbish any markings damaged by weather, vehicles, or persons, at no additional cost to the Owner.

3.4 PAVEMENT RESTORATION

A. In areas outside the Work areas where existing pavement is damaged due to the Contractor’s operations, the Contractor shall restore the area back to a condition equal to or better than the condition prior to damage at no additional cost to the Owner.

*** * * END OF SECTION * * ***

SECTION 02584

MANHOLES

1. GENERAL

1.1 DESCRIPTION OF WORK

A. The work consists of constructing manholes and the rebuilding or rechanneling of existing manholes in accordance with the Contract at locations shown on the Drawings.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Section 02222: Excavating, Backfilling and Compacting for Utilities.

B. Section 02240: Dewatering.

1.3 REFERENCE

A. City of Seattle (COS) Standard Specification Sections referenced in this specification shall be the 2011edition of the COS Standard Specifications for Road, Bridge and Municipal Construction, unless otherwise noted.

1.4 SUBMITTALS

A. Procedure: Conform to Specification Section 01300 - Submittal Procedures.

B. Submit manufacturer certificates on all manholes to be constructed and associated materials to be used for product verification with the COS Standard Specifications Sections 7-05, Maintenance Holes, Catch Basins, and Inlets and 9-12, Maintenance Holes, Catch Basins, and Inlets.

1.5 TRENCH SAFETY

A. Work in trench excavations over 4-feet deep shall comply with COS Standard Specifications Section 7-17.3(1)A7a, Trench Safety Systems.

2. PRODUCTS

2.1 MANHOLES

A. Manholes and associated materials shall be per COS Standard Specifications Section 7-05.2, “Materials” and the Drawings.

3. EXECUTION

3.1 NEW MANHOLES

A. Construct new manholes per COS Standard Specifications Section 7-05.3, Construction Requirements and the Drawings.

3.2 ADJUST EXISTING MANHOLE

A. The existing buried manhole, shown on the Drawings (Sheet C308), shall be adjusted so that the frame and lid match surrounding grades. Adjust the existing manhole to grade per COS Standard Specifications Section 7-05.3, Construction Requirements and 7-20, Adjustment of New and Existing Utility Structures to Finish Grade.

3.3 CLEAN EXISTING MANHOLES AND DRAINAGE STRUCTURES

A. Clean existing drainage structures and manholes per COS Standard Specifications Section 7-07, Cleaning Existing Drainage Structures.

* * * END OF SECTION * * *

SECTION 02605

OWS 421 STORMWATER PUMP SYSTEM

1. GENERAL

1.1 DESCRIPTION

A. This Section includes a submersible pump in OWS 421, piping, valves, flow meters, vaults, and accessories. This Section also includes a throttling valve and vault on the 8-inch forcemain located near MH 130A. Piping from the submersible pump to the weir tank at the long-term stormwater treatment (LTST) facility and piping for the meters, pump valve and throttling valve are included in this Section.

1.2 RELATED REQUIREMENTS SPECIFIED ELSEWHERE

A. Submittal Procedures: Section 01300

B. Shoring: Section 02150

C. Excavating, Backfilling and Compacting for Structures: Section 02221

D. Excavating, Backfilling and Compacting for Utilities: Section 02222

E. Dewatering: Section 02240

F. Precast Concrete Vaults: Section 03485

G. Variable Speed Motor Controllers: Section 16800

1.3 SUBMITTALS

A. Pump Product Data: Include certified performance curves and rated capacities of selected models; shipping, installed, and operating weights; shaft slenderness ratio; furnished specialties and accessories for each type and size of pump specified. Indicate pumps' operating point on curves. Highlight applicable sections of all manuals, tables and drawings to clearly show applicable items.

B. Shop Drawings: Show layout and connections for the pumps, valves, flow meter, and vaults. Include setting drawings with templates, directions for installation and anchor bolts, and other anchorages.

C. Wiring Diagrams: Detail wiring for power, signal, and control systems and differentiate between manufacturer-installed and field-installed wiring.

D. Maintenance Data: Include maintenance manuals for pumps and meters.

E. Product data for valves, flow meters, and vaults (including hatch doors).

F. Furnish detailed pump manufacturer's maintenance manuals and spare parts list. Provide a list of recommended spare parts and the recommended spare parts.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain same type of pump and motor through one source from a single manufacturer and as a packaged unit through the pump manufacturer.

B. Product Options: Plans indicate size, profiles, connections, and dimensional requirements of pump and are based on specific manufacturer type and model indicated. Other manufacturers' pumps with equal performance characteristics may be considered.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction.

D. Experience: The manufacturer will have minimum of ten (10) years experience in the building of similar pumps for wastewater systems.

E. Valves and operators and meters shall conform to all applicable AWWA and ANSI standards.

F. Provide valve and meter manufacturer’s certification that materials meet or exceed minimum requirements as specified.

G. All valves and meters of the same type shall be by a single manufacturer.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Retain shipping flange protective covers and protective coatings during storage.

B. Protect bearings and couplings against damage.

1.6 WARRANTIES

A. The pump and motor shall be covered by a full one (1) year warranty, including (100%) parts and labor. The warranty period shall begin at start-up of the equipment. **The warranty shall also include the cost of freight for the pump sent to and from the repair facilities**. This warranty shall not be limited by hours of running time.

B. The meters shall be covered by a full two (2) year warranty, including (100%) parts and labor. The warranty period shall begin at start-up of the meters. The warranty shall also include the cost of freight for the meter sent to and from the repair facility.

2. PRODUCTS

2.1 PUMP MANUFACTURERS

A. Hydromatic Model S6AX; or approved equal.

2.2 PUMPS, GENERAL

A. Furnish and install one submersible non-clog centrifugal solids handling explosion-proof submersible sewage pump. The pump shall be equipped with a 15-hp, submersible electric motor, connected for operation on 460 volts, three-phase, 60 hertz, seven wire service, with 50 feet of submersible cable (SUBCAB) suitable for submersible pump applications. The power cable shall be sized according to NEC and ICEA standards and shall also meet UL and CSA Approval. Motor shall be controlled with a variable frequency drive (VFD).

B. Pump shall be supplied with a mating cast iron 6-inch discharge connection and be capable of delivering 1,475 GPM (maximum) at 23 feet TDH and 970 GPM (minimum) at 21 feet TDH. Shut off head shall be 54.1 feet (minimum). The pump discharge shall be fitted with a 6" standard ASA 125 lb. flange, faced and drilled. All external mating parts shall be machined and Buna N rubber O-ring sealed on a beveled edge. All fasteners exposed to the pumped liquids shall be 300 series stainless steel.

C. Pumps shall be fitted with sufficient length stainless steel chain or stainless steel guide cable to extend from the pump to the top of OWS 421 (inlet structure) for pump retrieval via pump manufacturer’s system. Chain or cable size shall be according to the pump weight. The pump shall be capable of handling 3.5" spherical solids. The pump shall be non-overloading throughout the entire range of operation without employing service factor. The pump shall reserve a minimum service factor of 1.20. The performance curve submitted for approval shall state in addition to head and capacity performance, the pump efficiency, solid handling capability, and reflect motor service factor.

D. Finish: Manufacturer's standard paint applied to factory-assembled and -tested units before shipping.

E. Manufacturer's Preparation for Shipping: Clean flanges and exposed machined metal surfaces and treat with anticorrosion compound after assembly and testing. Protect flanges, pipe openings, and nozzles.

2.3 PUMP REMOVAL SYSTEM

A. The pump shall be automatically and firmly connected to the discharge connection, guided by no less than two 2-inch stainless steel guide bars extending from the top of the station to the discharge connection. Guide bars shall be continuous, without welded connections. The upper guide bracket shall be bolted to the hatch frame or structure wall near the top. There shall be no need for personnel to enter the OWS 421 to maintain the pump. Sealing of the pumping unit to the elbow discharge connection shall be accomplished by a machined metal-to-metal watertight contact. Sealing of the discharge interface with a diaphragm, 0-ring or profile gasket will not be acceptable. No portion of the pump shall bear directly on the floor.

2.4 PUMP CONSTRUCTION

A. Major pump components shall be of gray cast iron, ASTM A-48, Class 35B, with smooth surfaces devoid of blow holes or other irregularities. All exposed nuts or bolts shall be AISI type 316 stainless steel construction. All metal surfaces coming into contact with the pump fluids, other than stainless steel or brass, shall be protected by a factory applied spray coating of acrylic dispersion zinc phosphate primer with a polyester resin paint finish on the exterior of the pump.

B. Sealing design shall incorporate metal-to-metal contact between machined surfaces. Critical mating surfaces where watertight sealing is required shall be machined and fitted with Nitrile or Viton rubber 0-rings. Fittings will be the result of controlled compression of rubber 0-rings in two planes and 0-ring contact of four sides without the requirement of a specific torque limit.

C. Rectangular cross-sectioned gaskets requiring specific torque limits to achieve compression shall not be considered as adequate or equal. No secondary sealing compounds, elliptical 0-rings, grease or other devices shall be used.

2.5 PUMP CABLE ENTRY SEAL

A. The pump shall be triple protected with a compression fitting and two epoxy potted areas at the power cord entry to the pump. A separation between the junction box area of the pump and the motor by a stator lead sealing gland or terminal board shall not be acceptable. The cord cap assembly where bolted to the connection box assembly and the connection box assembly where bolted to the motor housing shall each be sealed with a Buna N rubber O-ring on a beveled edge to assure proper sealing.

2.6 PUMP MOTOR

A. The stator, rotor and bearings shall be mounted in a sealed submersible type housing. The stator windings shall have Class F insulation (155°C. or 311°F), and a dielectric oil-filled motor, NEMA B design (3 phase), NEMA L design (single phase). The pump and motor shall be specifically designed so that they may be operated partially dry or completely submerged in the liquid being pumped. The pump shall not require cooling water jackets. Dependence upon, or use of, water jackets for supplemental cooling shall not be acceptable. Stators shall be securely held in place with a removable end ring and threaded fasteners so they may be easily removed in the field without the use of heat or a press. Stators held by a heat shrink fit shall not be acceptable. Stators shall be capable of being repaired or rewound by a local motor service station. Units that require service only by the factory shall not be acceptable. No special tools shall be required for pump and motor disassembly.

B. Pump shall be equipped with heat sensors. The heat sensor(s) (one on single phase, two on three phase) shall be a low resistance, bi-metal disc that is temperature sensitive. It (they) shall be mounted directly in the stator and sized to open at 120°C or 130°C and automatically reset at 30–35°C differential. The sensor shall be connected in series with the motor starter coil so that the starter is tripped if a heat sensor opens. The motor starter shall be equipped with overload heaters (2-leg on single phase; 3-leg on three phase) so all normal overloads are protected by external heater block.

C. The combined service factor (combined effect of voltage, frequency and specific gravity) shall be a minimum of 1.20. The motor shall have a voltage tolerance of plus or minus 10%. The motor shall be designed for continuous operation up to 40 C (104 F) ambient and have a NEMA Class B maximum operating temperature rise of 80 degrees C. A motor performance chart shall be provided, upon request, showing curves for torque, current, power factor, input/output kW and efficiency. This chart shall also include data on starting and no-load characteristics.

D. The power cable shall be sized according to the NEC and ICEA standards and shall be of sufficient length to reach the junction box and electrical control panel in a continuous run without the need of any splices. The power cable shall be STW-A water resistant 600V, 60 degree C, UL and CSA approved and applied dependent on amp draw for size. The outer jacket of the cable shall be oil resistant chloroprene rubber. The motor and cable shall be capable of continuous submergence underwater without loss of watertight integrity to a depth of 65 feet.

E. The motor horsepower shall be adequate so that the pump is non-overloading throughout the entire pump performance curve from shut-off through run-out.

2.7 PUMP BEARINGS

A. The pump shaft shall rotate on two bearings. Motor bearings shall be permanently grease lubricated. The upper bearing shall be a single roller bearing. The lower bearing shall be a two row angular contact bearing to compensate for axial thrust and radial forces. Single row lower bearings are not acceptable. The bearings shall have a minimum B-10 life of 40,000 hours at or near BHP.

2.8 PUMP MECHANICAL SEAL

A. The pump shall have two mechanical seals, mounted in tandem, with an oil chamber between the seals. John Crane Type 21 or equal seals shall be used with the rotating seal faces being carbon and the stationary seal faces to be ceramic. The lower seal shall be replaceable without disassembly of the seal chamber and without the use of special tools. Pump-out vanes shall be present on the backside of the impeller to keep contaminants out of the seal area. Units that require the use of tungsten-carbide seals or foreign manufactured seals shall not be acceptable. Seals shall be locally available.

B. The pump shall be equipped with a 300 series stainless steel shaft sleeve under the lower seal for added protection to reduce costly shaft work in the event of seal failure. The sleeve shall be keyed to the shaft and use O-rings to prevent leakage under the sleeve. Units that do not include a stainless steel shaft sleeve shall not be considered equal or acceptable.

C. The pump shall be equipped with a seal leak detection probe and warning system. This shall be designed to alert maintenance personnel of lower seal failure without having to take the unit out of service for inspection or requiring access for checking seal chamber oil level and consistency.

D. There shall be an electric probe or seal failure sensor installed in the seal chamber between the two tandem mechanical seals. If the lower seal fails, contaminants that enter the seal chamber shall be detected by the sensor, which sends a signal to operate the specified warning device.

E. Units equipped with opposed mechanical seals shall not be acceptable.

2.9 PUMP SHAFT

A. Pump and motor shaft shall be the same unit. The pump shaft is an extension of the motor shaft. Couplings shall not be acceptable. The shaft shall be machined from solid 303 stainless steel.

2.10 PUMP IMPELLER

A. Impeller shall be of the two-vane, enclosed non-clogging design and have pump-out vanes on the front and backside of the impeller to prevent grit and other materials from collecting in the seal area. Impeller shall not require coating. Because most impeller coatings do not remain beyond the very early life of the impeller, efficiency and other performance data submitted shall be based on performance with an uncoated impeller. Attempts to improve efficiency by coating impeller shall not be acceptable.

B. Impellers shall be dynamically balanced. The tolerance values shall be as listed below according to the International Standard Organization grade 6.3 for rotors in rigid frames. The tolerance is to be split equally between the two balance planes that are the two impeller shrouds.

RPM	**Tolerance**
1750	.02 in. – oz./lb. of impeller weight
1150	.026 in. – oz./lb. of impeller weight
870	.03 in. – oz./lb. of impeller weight

C. The impeller shall be threaded shaft or tapered shaft and key driven. A 300 series stainless steel washer and impeller bolt shall be used to fasten the impeller to the shaft. Straight end shafts for attachment of the impeller shall not be acceptable.

2.11 PUMP VOLUTE AND SLIDING BRACKET

A. The pump volute and sliding bracket shall be of A48 Class 35B gray cast iron. The volute shall be made of close-grained cast iron conforming to ASTM A48 Class 30. It is to be one-piece, constant velocity equalizing pressure with smooth fluid passages large enough to pass any size solid that can pass through the impeller. It shall have single vane design. The sliding bracket assembly shall be a part of the pumping unit constructed so that when lowered to the discharge base/elbow, the vertical metal-to-metal seal provides a self-cleaning, non-clogging, UL listed, non-sparking assembly.

2.12 PUMP DISCHARGE BASE ELBOW

A. A discharge base elbow, designed to mount directly on the floor, shall be supplied for the pump. It shall have a standard 125 pound flange faced and drilled on the outlet side, with a machined mating inlet connection. The design shall be such that the pump to discharge connection is made without the need for any nuts, bolts or gaskets. The base elbow shall also anchor and align the two, 2” rails.

2.13 SUBMERSIBLE LEVEL TRANSDUCER

A. Siemens A100Di Loop Powered/4-20mA submersible level transmitter or approved equal.

B. Transducers that can be affected by foaming, turbulence, grease, suspended solids build-up, atmospheric changes, condensation, or false echoing shall not be acceptable.

C. Submersible sensory systems that use protective caps or cages to protect the sensing diaphram shall not be acceptable.

D. Transducers shall be FM and CSA intrinsically safe Class 1, Division 1, Groups A, B, C, and D with approved barrier.

E. Sensing methods utilizing technologies such as LVDTs, capacitance, or pneumatic elements shall not be acceptable.

F. Transducer specifications:
   1. Sealed breather system.
   2. One-inch pipe mount secured in place with type 304 stainless steel mounting clamps. Pipe shall be corrosion protected.
   3. Accuracy: 0.25% full scale.
   4. Pressure range: 0 to 15 psi.
   5. Housing: Teflon coated 316 stainless steel.
   6. Housing/Cable Sub-Assembly length: Assume 100 feet (exact length to be field determined).

2.14 DUCTILE IRON PIPE AND FITTINGS

A. Flanged-joint pipe shall be ductile iron, thickness class as required (Class 52, minimum), ANSI A21.15 (AWWA C115) for flanged pipe.
   1. Fittings: Fittings shall be ductile iron, ANSI A21.10 (AWWA C110).
   2. Flanges: Where flanged joints are shown on the Contract Plans, they shall utilize ductile iron, screwed-on flanges, 125 point class with oversized hub and conforming in all other respects to the requirements of ANSI B16.1. Flanges shall be refaced before shipment.
   3. Flange Gaskets: Synthetic rubber gaskets, pressure gaskets, min. 350 psi test pressure and 250 psi working pressure, U.S. Pipe Co. “Flange-tyte,” American Cast Iron Pipe Co. “Toruseal” or approved equal.
   4. Flange Bolts, Nuts and Plugs: Bolts and nuts shall be standard machine bolts with square heads and cold-pressed hexagon nuts. Studs with two (2) cold-pressed hexagon nuts shall be used where required or necessary. Bolts and nuts shall conform to the requirements of ASTM Designation A-307, Grade B and ANSI Standard B18.2. Stud bolts and nuts shall conform to the requirements of ASTM Designation A-193, Grade B7, ANSI Standard B16.5 and ANSI Standard B18.2. Bolts and nuts shall be zinc-coated steel, or stainless steel. Watertight plugs shall be U.S. Pipe & Foundry Co. No. U-364, the equivalent Pacific States Cast Iron Pipe Co. item, or equal.
   5. Special fittings: Special fittings not available in ductile iron may be cast iron or fabricated or coated welded steel. Design and wall thickness of fabricated fittings shall be subject to approval by the Engineer.

B. Mechanical-Joint pipe: AWWA C151, Class 52 unless otherwise indicated, with mechanical-joint, bell- and plain-spigot end unless flanged ends are indicated.
   1. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
      a. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

C. Restrained Joints: Where indicated, ductile iron fitting joints shall be restrained with Megalug restraint or approved equal. Restrained joints with retainer glands are not acceptable.

2.15 VAULTS AND DOORS

A. See Specification Section 03485 – Precast Concrete Vaults and the Drawings.

2.16 FLEXIBLE COUPLINGS

A. General: Fabricate from materials suitable for system fluid and that will provide flexible pipe connection.

B. Cast Iron Flanged Coupling Adaptor:
   1. Use for ductile iron pipe 12-inches and under to connect plain end pipe to flanged pipe or equipment.
   2. Body: Gray iron ASTM A126 Class B or malleable iron ASTM A47. Bolt circle, bolt size and spacing conform to ANSI 150 pound flange drilling.
   3. Follower: Ductile iron ASTM A536.
   4. Gasket: Grade 30 specially compounded rubber of all new materials.
   5. O-Ring: Grade 60.
   6. Cross and tee bolts: Stainless steel (316).
   7. Finish: Shopcoat enamel.
   8. Manufacturer: Smith-Blair, Romac, or equal.

C. Cast Coupling:
   1. Use for ductile pipe 16 inches and under to connect two plain ends.
   2. Sleeve: Ductile iron ASTM A536. Ends have a smooth inside taper for uniform gasket seating.
   3. Followers: Ductile iron ASTM A536. Follower thickness shall depend on coupling size as determined by manufacturer.
   4. Gaskets: Grade 30 specially compounded rubber of all new materials.
   5. Bolts and Nuts: Stainless steel (316).
   6. Finish: Shopcoat enamel.
   7. Manufacturer: Smith-Blair, Romac, or equal.

2.17 FLANGED COUPLING ADAPTERS

A. Manufacturer: Romac Industries, Inc. style FCA501 or approved equal.

B. Flange and through bolts, including nuts, shall be made of 304 stainless steel.

C. Flange body shall be ductile iron per ASTM A536, Grade 65-45-12 with ANSI Class 150 drilling.

D. Gasket shall be SBR per ASTM D2000 MBA 710, compounded for water and sewer service. Flange O-ring gasket shall be NBR.

2.18 GATE VALVE (NON-BURIED)

A. Iron Body and Bronze Trim:
   1. Size: 3-inch and over.
   2. Type:
      a. Resilient seated: For horizontal pipe runs.
   3. Rating: 200 psi W.O.G.
   4. AWWA C-509 or C-515.
   5. Ends: Flanged.
   6. Stem: Nonrising unless otherwise specified.
   7. Stem Seals: Neoprene "O"-Ring.
   8. Manual Operators:
      a. Direction of Rotation to Open: Counterclockwise, with operator marked to show direction to open.
      b. Type: Handwheel

2.19 GATE VALVE (DIRECT BURIED)

A. Gate Valves: AWWA C509 or C515
   1. Minimum Working Pressure: 200 psig.
   2. End Connections: Mechanical or flanged as indicated.
   3. Include AWWA 2-inch square operator nut that opens valve in counterclockwise rotation.
   4. Interior Coating: Comply with AWWA C550.

B. Valve Boxes: Two-piece cast iron equipped with suitable extension for 36- to 65-inch depth per COS Standard Plan Nos. 315a and 315b and COS Standard Specifications Section 9-30. Include top sections and lids designed for traffic loads.

2.20 CHECK VALVES

A. Swing Check Valves:
   1. Type: Full opening, with outside lever with adjustable weights.

2. Size: 3-inch and larger.
3. AWWA C508
4. Body and Trim: Iron body, bronze mounted.
5. Ends: Flanged.
6. Disc Facing: Bronze.
7. Hinge Pins: Stainless Steel.
8. Outside lever position: Right hand side when facing the valve inlet.
9. Lever Seal:
    a. 3-inch through 12-inch valves: hinge pin extended through outside lubricated bronze bushing and O-ring seals.
10. Lubrication: Grease fittings for outside lubrication of lever seals.
11. Valve Position: check valve shall be installed in horizontal runs only.
12. Manufacturer: Flowmatic or approved equal.

2.21 ECCENTRIC PLUG VALVE

A. Eccentric Plug Valve: AWWA C517
1. Size: 4-inch and over.
2. Rating: Drop-tight at 175 psi.
3. Body: Cast iron, ASTM A126, Class B.
4. Plug: Cast iron, ASTM A126 with portion of plug in body cavity coated with Buna-N rubber.
5. Body Seats: Stainless steel, ASTM A276, Type 304 or nickel (90% pure and at least 1/8” thick after machining).
6. Packing: Buna V-flex or TFE.
7. Ends: Flanged.
8. Manual Operator: Handwheel.

2.22 ELECTRONICMAGNETIC FLOW METERS

A. Manufacturer:
1. Flow meters shall be ABB, Siemens or approved equal.
2. Flow meter approved and CSA certified for Class1, Div. 2, Groups A, B, C, and D hazardous conditions.

B. Operating Conditions
1. Flow: 100 gpm to 2,000 gpm.
2. Maximum Pressure: 120 psi.
3. Liquid Temperature: 14 to 158 Degrees Fahrenheit.
4. Liquid: Stormwater.
5. Ambient Temperature: 14 to 140 Degrees Fahrenheit.
6. Accuracy: 0.2% +/-

C. Detector
1. Detector shall be mounted in the flow meter vault in a Class 1, Div. 2 hazardous (classified) location.

2. Mounting Style: Flanged, ANSI 150.
3. Case Material: Carbon Steel.
4. Flange Material: Carbon Steel.
5. Lining: Polyurethane.
6. Electrodes: 316 Stainless Steel.
7. Grounding electrodes: 316 Stainless Steel.
8. Measuring Tube Material: 304 Stainless Steel.

D. Transmitter
1. Shall be panel mounted in an unclassified location.
2. Digital Input Function: Totalizer control.
3. Output Signals:
    a. Current output, 4 -20 mA.
    b. Two digital isolated contacts 30 Vdc.
4. Power Supply: 120V.
5. Case: Aluminum alloy.
6. Remotely mounted.
7. Coating: Acrylic resin-baked coating, pearl-gray colored.

E. Signal Cable
1. Provide manufacturer’s signal cable between detector and transmitter. Cable shall be sealed at detector end for use in Class 1, Div 2 hazardous (classified) location. Cable shall be ordered to length – no splice

2.23 ADJUSTABLE PIPE SADDLE SUPPORTS

A. Pipe supports shall be suitable for ductile iron and HDPE pipe. Use a neoprene liner on the saddle if needed for a full contact fit.

B. Supports to have over-sized anchorable base plates, ASTM A36 sheet steel (0.25” thick minimum).

C. Threaded Stud: ASTM A36, rolled thread Grade ASTM A307.

D. Supports shall have a corrosion resistant, galvanized finish.

3. EXECUTION

3.1 VALVE AND METER VAULTS AND ACCESS DOORS

A. See Section 03485 – Precast Concrete Vaults for installation methods.

3.2 SUBMERSIBLE PUMP

A. Pumps, pump equipment, and accessories shall be installed in strict accordance with the manufacturer’s installation instructions and recommendations and as shown on the Plans.

B. After complete installation, the pumps shall be tested in accordance with manufacturer's test instructions and recommendations. The pump manufacturer shall provide a formal test procedure and forms for recording test results and parameters.

C. Provide 4 hours of on-site field service by a qualified service engineer or qualified technician to inspect and test the completed installation and to instruct the Owner and its staff in the proper operation and maintenance of the flow meter.

D. The guide rail system shall be tested to ensure smooth pump removal and installation.

3.3 PIPE AND FITTINGS

A. Installation of Buried Pipe
   1. See Section 02222 – Excavating, Backfilling and Compacting for Utilities.
   2. Lines and Grades:
      a. In position and to accurate lines, elevations and grades as shown on the Drawings.
      b. Slope to drain where possible.
      c. Lay pipe to grade between control elevations shown on the Drawings when slope is not indicated.
   3. Securing In Place: By blocking, brackets, anchors, clamps or other approved methods to secure pipe in place to withstand test pressure and thermal operating forces without movement.

B. Installation of Interior Pipe
   1. Complete installation to present neat orderly appearance.
   2. Do not block openings or passageways with piping.
   3. Run piping parallel to walls, floors or ceilings of building.
   4. Keep piping free from contact with structure or installed items.
   5. Allow clearances for expansion and contraction of pipe.
   6. Placement of Vertical Piping:
      a. Secure at sufficiently close intervals to keep pipe in alignment and to support weight of pipe and contents.
      b. Install supports at each floor or vertically at intervals of not more than 10 feet
      c. If piping is to stand free of support, or if no structural element is available for support during construction, secure in position with wooden stakes or braces fastened to pipe.
   7. Placement of Horizontal Piping:
      a. Support at sufficiently close intervals to maintain alignment and prevent sagging.
      b. Install hangers or supports at ends of runs or branches and at each change of direction or alignment.

8. Support at Equipment: Install to not induce strain on equipment during or subsequent to the installation of pipework.

C. Bell and Spigot, Push-On, and Mechanical Joint Pipe Installation
   1. Push on Joint Installation: Per manufacturer's instructions.
   2. Mechanical Joint Installation: Per manufacturer's instructions.
   3. Set grade to meet requirements of piping system and applicable code prior to installing joint.
   4. Restrained Joint Installation: Per manufacturer’s instructions.

D. Flanged Pipe Installation
   1. Tighten flange bolts so that gasket is uniformly compressed and sealed.
   2. Do not distort flanges.
   3. Flange bolts to project 1/8 to 3/8-inches beyond the face of nut after tightening.

E. Threaded Joint Installation
   1. Threads: ANSI B1.201, NPT.
   2. Cut threads full and clean with sharp dies.
   3. Ream ends of pipe after threading and before assembly to remove burrs.
   4. Leave not more than three pipe threads exposed at each connection.
   5. Joint Sealer - Teflon thread tape.

F. PVC Pipe Installation
   1. Cutting:
      a. Cut pipe with a knife or hand saw.
      b. Make cuts square with pipe.
      c. Remove burrs by smoothing edges with a knife, file, or sandpaper.
   2. Solvent Joints:
      a. Clean joint surfaces.
      b. Coat with solvent cement and join.
      c. Hold joint together until cement takes hold.
      d. Use sufficient cement so that a bead of cement is formed between pipe and fitting at socket entrance.
   3. Threaded Joints: Tighten by strap wrench to not more than one full turn beyond hand tight.

G. Testing
   1. General:
      a. All pipe and fittings shall be pressure-tested as specified herein.
      b. The Contractor shall furnish all materials, equipment, and labor for testing and retesting the piping system.
      c. Each system may be tested as a unit or in sections, but each complete system shall successfully meet the requirements specified herein before acceptance by the Engineer.

d. Should any defects appear in the pipe or fittings, the necessary repair shall be made, and the line retested until it shall meet the requirements.

e. The Contractor shall take all necessary precautions to prevent any joints from drawing while the pipelines and their appurtenances are being tested and he shall at his own expense repair any damage to the pipes and their appurtenances or to any other structures or equipment resulting from or caused by these tests.

f. The Contractor shall inform the Engineer at least two days in advance of the time set for testing the piping system.

2. All piping shall be hydrostatically pressure tested as specified herein. Test pressure for piping shall be 75 psig.

3. The test shall be made by closing valves or providing bulkheads or plugs and filling the pipeline with water. Provisions shall be made for release of all air in the lines. Lines may be filled with water sometime before testing to allow for absorption of water by pipe or joint material. The test pressure shall be maintained a minimum of one hour or sufficiently longer to permit the Engineer to make an inspection of the system. During the test, pipe, fittings and joints shall be completely tight.

3.4 VALVES

A. General: All valves, valve boxes, and accessories shall be installed in a manner and location as shown on the Plans or as required for the application and in accordance with manufacturer's instructions. Size of valve is equal to line piping in which valve is installed unless otherwise noted on the Plans. Support all valves where necessary. In case of conflict between these specifications and a governing code, the higher standard shall prevail.

B. Accessories:

1. Provide all accessories necessary for proper valve operation as specified or required for the application. Buried valves shall be installed with 2-inch square operating nuts and adjustable cast iron valve box with cover. Provide sufficient number of T wrenches for buried valve operation for all sizes of operating nuts and for placement at convenient locations. Buried valves shall be provided with extension stems if the operating nut would be 36 inches or more below the ground surface.

2. Provide extension stems for submerged valve service where indicated on the plans or required for convenient operation. Provide sufficient number of adjustable cast iron stem guides such that the ratio of unsupported length of stem to radius of stem does not exceed 200. Provide suitable floor stands with operators at approximately 30-inch height where indicated on plans or required for proper valve operation. Small lever or handwheel operated valves may utilize handrails or other suitable structure for support of extension stems.

C. Valve Operators: Valves shall be installed with the operator in a position for convenient operation. Particular care shall be taken to assure that space is available for operation of lever or handwheel operated valves without interference from walls, piping or equipment. Any valve which is installed, in the opinion of the Engineer, in a manner that operation is inconvenient shall be modified or removed and reinstalled in a manner acceptable to the Engineer. Operators for manual valves shall be lever or handwheel as is standard with the manufacturer unless another type of operator is recommended by the manufacturer.

D. Valve Identification:
1. Provide with numbered brass discs attached to valve by brass chain.
2. Provide valve chart indicating valve tag number, location of valve, service, and normal position of valve.
3. Provide valve tag list to Engineer for approval prior to tagging.
4. All globe, angle and check valves shall have their composition discs selected in accordance with the line service, either for cold water or hot water. Valves shall be tagged with a permanent label under handwheel indicating type of disc installed.
5. Valves shall be fully identified by the manufacturer including size, manufacturer's name, and pressure rating.

E. Adjustments
1. Check and adjust valves and accessories for smooth operation. Lubricate in accordance with manufacturer's recommendations. All globe, angle and gate valves shall have their stuffing boxes packed with an excess of 30 percent of packing (for future adjustment).

F. Testing
1. Test with piping as per this Section.

G. Throttling Valve:
1. Operate MH 130A pump all full speed to adjust flow through the 8-inch forcemain to 530 GPM. Coordinate adjustment with flow meter near OWS 421.

3.5 MECHANICAL EQUIPMENT, GENERAL

A. If a specific dimensioned location is not shown for interconnections or smaller system elements, the Contractor shall select appropriate locations and show them on Shop Drawing submittals for review.

B. Equipment and materials shall be new and without imperfections and shall be erected in a neat and workmanlike manner; aligned, leveled, cleaned and adjusted for satisfactory operation; installed in accordance with the recommendations of the manufacturers and the best standard practices for this type of work so that connecting and disconnecting of piping and accessories can be readily made and so that all parts are easily accessible for inspection, operation, maintenance and repair.

C. Cooperate with all trades in furnishing materials and information for correct location, in proper sequence, of all sleeves, bucks, inserts, foundations, wiring, etc.

D. Piping connections to equipment shall be made with unions or flanges to permit dismantling. Flanges and unions shall also be installed in the piping systems to permit disassembly consistent with good installation practice and as required for removal of connected equipment from place of installation.

E. Plan all work so that it proceeds with a minimum of interference with other trades.

F. Openings required in the construction for the installation of the work under these specifications shall be coordinated with work of all other trades.

G. Contractor shall pay for all extra cutting and patching made necessary by his failure to properly direct such work at the correct time.

H. Furnish and install at all inter-connections between piping systems of dissimilar materials and at all connections of piping systems to equipment where piping and equipment are of dissimilar materials.

I. Couplings shall be specifically designed for the purpose of electrically isolating pipelines from other piping systems or equipment.

J. Shop weld to maximum extent possible.

K. Use welders certified in accordance with the latest requirements of the American Welding Society "Standard Qualifications Procedures".

L. Repair protective coating and linings to a condition equivalent to the factory applied coating or lining.

M. Install coupling at ends of pipe to be welded to provide access for replacing protective lining.

N. The Contractor shall furnish the necessary materials and construct concrete foundations for all equipment installed by him, even though such foundations may not be indicated on the Plans.

O. The Contractor shall make an allowance of at least one inch for grout under the equipment bases. All shims shall be removed. Unless otherwise approved, all grout shall be an approved nonshrinking grout.

P. Where practicable, the grout shall be placed through the grout holes in the base and work outward and under the edges of the base and across the rough top of the concrete foundation to a peripheral form so constructed as to provide a suitable chamber around the top edge of the finished foundation.

Q. All motors, valves, control devices, specialties, etc., shall be so located as to provide for easy access for operation, repair and maintenance.

R. Provide lubrication for the operation of all equipment until acceptance.

S. Provide with a chart listing each piece of equipment, the proper type of oil or grease required and recommended frequency of lubrication.

T. Contractor shall be required to run in all bearings and, after they are run in, shall drain and flush bearings and refill with a new oil charge.

U. Oil and lubrication fittings shall be located within reach from the operating surface. In order to meet these requirements with equipment as furnished, minor deviations from the Plans may be made as favorably reviewed by the Owner

3.6 FLOW METERS

A. Flow meters shall be installed in strict conformance with the manufacturer's instructions and as shown on the Plans. The installation and initial operation shall be certified on the manufacturer's installation and operation form(s).

B. During pump station start-up, field test the flow meters in accordance with manufacturer's instructions to demonstrate compliance with the performance requirements specified.

C. Meter manufacturer:
   1. Provide 4 hours of on-site field service by a qualified service engineer or qualified technician to inspect and test the completed installation and to instruct the Owner and its staff in the proper operation and maintenance of the flow meter.

3.7 TRANSDUCER

A. Transducer shall be installed in strict conformance with the manufacturer's instructions and as shown on the Drawings.

3.8 PIPE SUPPORTS

A. Pipe supports shall be installed in strict conformance with the manufacturer’s instructions and as shown on the Drawings.

* * * END OF SECTION * * *

SECTION 02610

PIPES AND FITTINGS

1. GENERAL

1.1 DESRIPTION OF WORK

A. This Section covers buried storm sewer drains, HDPE, PVC, and Ductile Iron pipe and fittings as shown on the Drawings.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Section 01300: Submittal Procedures.

B. Section 02222: Excavating, Backfilling and Compacting for Utilities.

C. Section 02240: Dewatering.

D. Section 02720: Storm Drainage.

1.3 REFERENCE

A. City of Seattle (COS) Standard Specification Sections referenced in this specification shall be the 2011 edition of the COS Standard Specifications for Road, Bridge and Municipal Construction, unless otherwise noted.

1.4 SUBMITTALS

A. Procedure: Conform to Specification Section 01300 - Submittal Procedures.

B. The Contractor shall provide submittals for all materials.

C. Submittals shall identify the proposed utility use(s) for each item submitted.

D. Prior to shipping any material to the site, submit the following:
   1. Manufacturer's product data including pipe, pipe accessories, valves, and appurtenances. Provide manufacturers certificates for materials that meet or exceed these Specifications. Certifications shall be submitted to the Engineer by the Contractor prior to pipe installation.
   2. Submit a 1-foot long sample of each pipe for acceptance by the Engineer prior to fabricating pipe.
   3. Pipe manufacturer's qualifications.

E. Prior to fabrication of pipe components, submit the following:
   1. Shop drawings for any specialty fabricated fittings.

2. Pipe fabricator’s qualifications and certifications with applicable standards.

F. Prior to installation of any components, submit the following:
1. Pipe installer’s qualifications.
2. Plan(s) showing pipe installation sequence and schedule.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Labeling: The following information shall be continuously marked on the pipe and spaced at intervals not to exceed 5 feet:
1. Name and/or trademark of the pipe manufacturer.
2. Nominal pipe size.
3. Standard Dimensional Ratio (SDR)/Schedule.
4. Material Classification.
5. Manufacturing Standard Reference.
6. A production code from which the date and place of manufacture can be determined.

B. Transportation is the responsibility of the Contractor, who shall be liable for all damages prior to and during transportation to site.

C. During shipment and storage, the HDPE pipe shall be wrapped in relatively impermeable and opaque protective covers.

D. Inspect materials delivered to the site for damage. Unload and store with minimum of handling. Store materials onsite in enclosures or under protective coverings. Store pipe and fittings in a flat, horizontal position, and under cover, out of direct sunlight. Do not sort materials directly on the ground. Keep inside of piping free of dirt and debris.

E. Handling, storage, and care onsite are the responsibility of the Contractor prior to, during and after installation. Handle pipes, fittings, and other accessories in a manner that ensures delivery to the point of installation in sound, undamaged condition. Do not drop pipe. Carry, do not drag, pipe to the point of installation.

1.6 REFERENCES

A. Referenced Standards: This section incorporates by reference the latest revision of the following documents. It is part of this section as specified and modified. In case of conflict between the requirements of this section and that of the listed documents, the requirements of this section shall prevail.

B. American Society for Testing and Materials (ASTM) D638-10: Standard Test Method for Tensile Properties of Plastics.

C. ASTM D695-10: Standard Test Method for Compressive Properties of Rigid Plastics.

D. ASTM D3132-84(1996): Standard Test Method for Solubility Range of Resins and Polymers (Withdrawn 2005).

E. ASTM D3261-10a: Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.

F. ASTM D3350-10a: Standard Specification for Polyethylene Plastics Pipe and Fittings Materials.

G. ASTM F679-08: Standard Specification for Poly(Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings.

H. ASTM F714-10: Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter.

I. ASTM F1055-98(2006): Standard Specification for Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene Pipe and Tubing.

1.7 QUALIFICATIONS FOR HDPE PIPE INSTALLATION

A. The pipe installer shall be qualified by experience in installation of HDPE pipe.

B. Contractors are considered qualified by installing a minimum combined total of 15,000 feet of HDPE pipe using thermal fusion joining on at least three (3) separate projects.

C. The person/persons performing pipe joining by butt-fusion welding shall be certified as capable of conducting butt-fusion welding by the pipe manufacturer or manufacturer’s authorized representative.

1.8 QUALITY ASSURANCE

A. Applicable Standards
   1. Construction and material quality standards for this section shall be as described in the COS Standard Specifications for Road, Bridge and Municipal Construction, 2011 edition: Divisions 7 and 9, unless otherwise noted.

B. Testing Before Acceptance:
   1. The first section of pipe, not less than 300 feet in length, installed by each of the Contractor's crews shall be tested, in accordance with these Specifications, in order to qualify the crew and/or the materials.
   2. Pipe laying shall not be continued more than an additional 300 feet until the first section shall have been tested, in accordance with these Specifications, successfully.

C. Final Acceptance:

1. Prior to final inspection all pipelines shall be flushed and cleaned and all debris removed.
2. Before storm sewer lines are accepted, all lines shall be tested as specified herein and inspected for line and grade by checking each section between manholes for alignment. A full circle of light shall be seen by looking through the pipe at a light held in the manhole at the opposite end of the section of storm sewer line being inspected.
3. Deflection test shall be performed on all flexible pipes in accordance with COS Standard Specification Section 7-17.3(4)H, Deflection Test for Flexible Pipe.
4. Any corrections required shall be made at the expense of the Contractor and the line shall be retested until accepted by the Engineer.

2. PRODUCTS

2.1 HDPE MATERIAL

A. HDPE pipe and fittings shall be extruded from an extra-high molecular weight, high-density polyethylene compound conforming to ASTM D3350 for a PE 3408 material with a cell classification as shown in the Pipe Schedule (Table 1), or better. This material shall have a compressive yield strength of 1,600 psi when tested and analyzed by ASTM D695, and a tensile yield strength of 3,200 psi when tested and analyzed by ASTM D638.

Table 1

System	Nominal Diameter	SDR	ASTM D3350 Cell Classification
HDPE Gravity Line	8 inch	17	345434C
HDPE Gravity Line	28 inch	17	345434C
HDPE Forcemain	8 inch	17	345434C

B. The polyethylene compound shall be suitably protected against degradation by ultraviolet light by means of carbon black, well dispersed by precompounding in a concentration of not less than 2 percent.

C. The manufacturer shall be listed with the Plastic Pipe Institute as meeting the recipe and mixing requirements of the resin manufacturer for the resin used to manufacture the pipe and fittings for this project.

D. HDPE products shall contain no recycled compounds except that generated in the manufacturer’s own plant from resin of the same specifications from the same raw material supplier.

2.2 HDPE PIPE

A. HDPE pipe meeting the requirements of this Section shall be used for all storm sewer piping at the locations shown on the Drawings.

B. The same manufacturer shall supply polyethylene pipe and fittings. Pipe and fittings from different manufacturers shall not be interchanged.

C. Pipe and fittings shall be of the nominal diameter shown on the Drawings. All pipe sizes shall conform to ASTM F714.

D. The maximum allowable hoop stress shall be 1,000 psi at 140 degrees Fahrenheit.

E. The polyethylene pipe shall be homogenous throughout and free of visible cracks, holes, foreign inclusions, or other injurious defects. Any pipe with nicks, scrapes, or gouges deeper than 5 percent of the nominal wall thickness shall be rejected. The pipe shall be uniform in color, opacity, density, and other physical properties.

F. Joints and pipe connections shall be thermal butt-fusion. No mechanical couplings shall be used unless shown on the Drawings or approved by the Engineer.

2.3 HDPE FITTINGS

A. HDPE fittings shall be from the same manufacturer as the pipe, molded or fabricated from HDPE pipe and shall have the same or numerically smaller SDR than pipe connecting to the fitting. HDPE fittings shall be molded, for sizes 6-inch and smaller, if manufactured as a standard item. All other HDPE fittings shall be fabricated from HDPE pipe by means of thermal butt-fusion unless otherwise noted.

B. All reducing tees shall be factory-molded if available as a standard item by any manufacturer having pipe, meeting this section. If not available as a standard item, branch saddle reducing tees shall be used. Reducers shall be shop-manufactured. Field fabricated branch saddle connections are not allowed, except where shown on the Drawings.

C. All molded HDPE fittings shall have the same or higher pressure rating as the pipe when installed in accordance with the latest technical specifications. All fabricated HDPE fittings shall have the same or higher pressure rating as the adjoining pipe when installed in accordance with the manufacturer’s recommendations.

2.4 HDPE PIPE CONNECTIONS

A. Joints and pipe connections shall be by thermal butt-fusion, except where shown on the Drawings or approved by the Engineer. No mechanical couplings shall be used except where shown on the Drawings.

2.5 HDPE PIPE TEMPORARY CONNECTIONS

A. Couplers used for temporary piping connections shall be mechanical type with adjustable bolts and teeth to grip the HDPE pipe. Fasteners shall be stainless steel and the coupler body shall be galvanized or painted. Couplers shall be Style 995 HDP as manufactured by Victaulic, or approved equal.

2.6 HDPE PIPE FLANGES

A. Flange backup rings shall be stainless steel with 150-pound, ANSI B16.5 standard dimensions unless specified otherwise. Flanges shall be complete with one-piece, polyethylene molded flange adapter. Flanged connections shall have the same or greater pressure rating as the pipe. All fasteners shall be 304 stainless steel and shall be assembled with anti-seize compound as recommended by the manufacturer. Gaskets shall be installed at all flanged connections.

2.7 FLANGED COUPLING ADAPTER FOR HDPE PIPE

A. Flanged coupling adapters shall be Romac Industries Series FCA501 or equal. Gaskets shall be manufactured from Buna N. All ductile parts shall be coated with fusion bonded epoxy in accordance with AWWA. Flanged coupling adapters shall meet the requirements of AWWA C219. All nuts and bolts shall be stainless steel.

2.8 BLIND FLANGE FOR HDPE PIPE

A. Blind flanges shall be made of HDPE.

2.9 GASKETS FOR HDPE PIPE

A. Gaskets shall be flat ring, 1/8-inch Viton.

2.10 HARDWARE FOR HDPE PIPE

A. Bolts, nuts, washers, and miscellaneous hardware shall be 304 stainless steel unless noted otherwise on the Drawings or in these Specifications. All hardware shall be assembled with anti-seize compound as recommended by the manufacturer.

2.11 ELECTROFUSION COUPLING FOR HDPE PIPE

A. Electrofusion couplings shall be used where shown on the Drawings, in situations where welding machine access is difficult or impossible, or as determined by the Engineer.

B. Electrofusion couplings shall be a rigid straight coupler constructed from injection-molded polyethylene with embedded heating coils. Electrofusion couplings shall be manufactured in accordance with ASTM F1055. Electrofusion couplers shall be Frialen Straight Couplers, as manufactured by Friatec, or equivalent.

2.12 GATE VALVE

A. Gate valves shall be in accordance with Section 02605 – OWS 421 Stormwater Pump System.

2.13 DUCTILE IRON PIPE

A. Conform to Section 02605 – OWS 421 Stormwater Pump System.

2.14 DUCTILE IRON AND GRAY IRON FITTINGS

A. Conform to Section 02605 – OWS 421 Stormwater Pump System.

2.15 POLYVINYL CHLORIDE (PVC) PIPE AND FITTINGS

A. An alternative pipe material for the 24-inch HDPE storm sewer pipe is PVC pipe, PS46 as manufactured by JM Eagle or approved equal.

B. Joints shall be in accordance with the manufacturer's recommendation and meet the requirements of ASTM D3132.

C. Pipe connections and fittings shall be in accordance with the manufacturer's recommendation.

3. EXECUTION

3.1 PIPE INSTALLATION

A. Install storm sewer pipe in accordance with Specification Section 02720 - Storm Drainage and the Drawings.

3.2 CONFORMANCE TESTING

A. Samples of materials delivered to site may be collected for testing to verify conformance with this Specification, at the Engineer's discretion.

B. Samples, if required, will be obtained by the Engineer. All testing performed will be paid for by the Owner.

3.3 HDPE PIPE JOINING

A. HDPE pipe shall be cut, fabricated and installed in strict conformance with the pipe manufacturer's recommendations.

B. HDPE pipe and fitting connections shall be joined by thermal butt fusion and be of the same type, grade, and class of polyethylene compound and supplied from the same raw material supplier. Butt fusion of pipes and fittings shall be performed in accordance with ASTM D3261 and the pipe manufacturer's recommendations.

C. Butt-fusion shall be done with equipment recommended by the pipe manufacturer. Butt-fusion equipment shall meet the pipe manufacturer's recommended fusion temperature, pressure, and alignment.

D. Butt-fusion joining shall be 100 percent efficient offering a joint weld strength equal to, or greater than the tensile strength of the pipe. Solid HDPE pipe shall have airtight joints.

E. Where used, electrofusion couplings shall be installed in accordance with the manufacturer's recommendations.

3.4 HDPE PIPE MECHANICAL CONNECTIONS

A. Mechanical connections of the polyethylene pipe to auxiliary equipment, such as valves and other piping systems, shall be through flanged connections that shall consist of the following:
   1. A polyethylene molded flange adapter (MFA) shall be thermally butt-fused to the ends of the pipe.
   2. Backup rings shall be used behind the MFA.
   3. Fasteners shall be of sufficient length to show a minimum of three complete threads when the joint is made and tightened to the manufacturer's standard. The Contractor shall retorque the nuts after 4 hours.

B. Assembly: Prior to connecting flanged pipe, the faces of the flanges shall be thoroughly cleaned of all oil, grease, and foreign material. The gaskets shall be checked for proper fit and thoroughly cleaned. Care shall be taken to ensure proper seating of the flange gasket. All bolted connections shall be tightened with a torque wrench and bolts shall be tightened to the torque specified by the manufacturer of the HDPE flanges and/or backing rings and/or gaskets. Follow the manufacturer's specified bolt-tightening sequence. Bolts may be pre-tightened using conventional wrenches and/or air tools as long as the pre-tightening torque does not exceed approximately 50 percent of the final torque and the bolt-tightening sequence is followed. Do not attempt to flange up a pipeline that is too short by drawing the bolts together. If joints leak when the air pressure test is applied, the gaskets shall be removed and reset and bolts re-tightened.

3.5 ALLOWANCE FOR THERMAL EXPANSION/CONTRACTION

A. HDPE has a coefficient of thermal expansion of 1.2×10^{-4} ft/ft/deg F. HDPE pipe shall be installed with excess length between anchor points such that contraction caused by temperature drop to 40 degrees F will produce the length of pipe between two points shown on the Drawings. Amount of excess pipe depends on temperatures of pipe at the time of installation, according to Table 2:

Table 2	
Installation Temperature (degrees F)	**Excess Pipe Length (in./100 ft)**
50	1.4
60	2.9
70	4.3
80	5.8
90	7.2
100	8.6
120	11.5

3.6 HDPE PIPE CLEANING

A. Piping systems shall be cleaned and tested in accordance with the manufacturer's recommendation and as specified herein.

B. Prior to testing, pipelines shall be cleaned to remove shavings, welding slag, dirt, construction debris, and other foreign material and flushed with clean water at a minimum of 3 feet per second (fps) velocity.

3.7 HDPE PIPE LEAK TEST

A. Conduct pressure and leakage tests on newly installed pipelines and appurtenances, in accordance with a testing plan approved by the Engineer. The testing plan shall be developed in accordance with the minimum requirements included in this section. The Contractor shall furnish all necessary equipment and material and make taps in piping, as necessary, for testing as specified.

B. Conduct testing of all solid piping according to the following requirements:
   1. Conduct pressure and leakage tests on newly installed pipelines and appurtenances, in accordance with the reviewed testing plan.
   2. Furnish necessary equipment and material and make taps in piping, as necessary, for testing and as specified.
   3. Engineer will observe the tests.
   4. Provide two (2) working days advance written notice of start of testing to the Engineer.
   5. Test pressures and the type of test shall be pneumatic at 5 psig, unless otherwise specified.
   6. Separately test pressure pipe sections that can be isolated by valves.
   7. Make records of each piping system during the test to document the following:

a. Date of test.
b. Description and identification of piping tested.
c. Test pressure.
d. Remarks, including:
   1) Leaks (type, location)
   2) Repairs made on leaks
e. Certification by the Contractor and signed acknowledgement by the Engineer that tests have been satisfactorily completed.

8. Conduct testing of piping as follows:
   a. Initial Service Leak Test: Conduct with partially backfilled trench and joints left open for inspection, as field conditions permit and as approved by the Engineer.
   b. Final Acceptance Test: Conduct after trench has been completely backfilled.
   c. Expose all joints on buried piping to be pneumatically tested or subjected to an initial service leak test.

C. The general types of equipment required for pneumatic leak testing include the following:
   1. Pneumatic compressor separator-dryer system capable of providing oil-free dry air and equipped with one or more full capacity safety relief valves set at a pressure of not more than 105 percent of the required primary test pressure.
   2. Calibrated test gauge.
   3. Other miscellaneous equipment necessary to conduct the leak test.

D. The procedures for conducting the test are as follows:
   1. Perform pneumatic testing using accurately calibrated instruments and oil-free dry air.
   2. Perform initial service leak tests only on exposed piping. Perform initial leak testing by gradually bringing the piping system up to normal operating pressure and hold continuously for a minimum of 10 minutes. Examine joints and connections for leakage with soap bubbles. The piping system, exclusive of possible localized instances at pump or valve packing, shall show no visual evidence of leaking. Correct any visible leakage and retest as directed by the Engineer.
   3. Test all parts of the piping system at the test pressure specified.
   4. Take all necessary precautions to protect test personnel and Owner’s operating personnel from hazards associated with air testing.
   5. Secure piping to be tested to prevent damage to adjacent piping and equipment in event of a joint failure.
   6. Prior to test, remove or suitably isolate appurtenant instruments or devices that could be damaged by test.
   7. Apply soap bubbles to joints and connections for examining leakage.
   8. Apply maximum 10-psig preliminary pneumatic test to piping system prior to final leak testing, to locate visible leaks. Bleed pressure completely prior to conducting final leak testing.

9. Correct visible leaks, and repeat the preliminary test until all visible leaks are corrected.
10. Gradually increase pressure in the system to not more than ½ of specified test pressure.
11. Thereafter, increase pressure in steps of approximately 1/10 of specified test pressure until required test pressure is reached.
12. Maintain pneumatic test pressure continuously for a minimum 10 minutes and for such additional time as necessary to conduct soap bubble examination for leakage.
13. Correct visible leakage and retest as required by the Engineer.
14. The piping system, exclusive of possible localized instances at pump or valve packing, shall show no visual evidence of leakage.

E. Pipe and joints being tested shall be considered acceptable when tested at an average pressure of 5.0 pounds per square inch greater than atmospheric pressure when the section of line does not lose air for one hour.

* * * END OF SECTION * * *

SECTION 02720

STORM DRAINAGE

1. GENERAL

1.1 DESCRIPTION OF WORK

A. This section includes the requirements for installation of manholes, storm drain gravity pipes and storm drain forcemains.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Section 01300: Submittal Procedures.

B. Section 02150: Shoring.

C. Section 02221: Excavating, Backfilling and Compacting for Structures.

D. Section 02222: Excavating, Backfilling and Compacting for Utilities.

E. Section 02240: Dewatering.

F. Section 02584: Manholes.

G. Section 02610: Pipes and Fittings.

1.3 REFERENCE

A. City of Seattle (COS) Standard Specification Sections referenced in this specification shall be the 2011edition of the COS Standard Specifications for Road, Bridge and Municipal Construction, unless otherwise noted.

1.4 SUBMITTALS

A. Procedure: Conform to Specification Section 01300 - Submittal Procedures.

1.5 QUALITY ASSURANCE

A. Applicable Standards:
1. Construction and material quality standards for this Section shall be as described in the COS Standard Specifications for Road, Bridge and Municipal Construction, 2011 Edition; Division 7.
2. Construction standards for this Section shall be as shown in the COS Standard Plans for Municipal Construction, 2011 Edition.

B. Testing before acceptance:

1. The first section of pipe, not less than 300 feet in length, installed by each of the Contractor's crews shall be tested in order to qualify the crew and/or the material.
2. Pipe laying shall not be continued more than an additional 300 feet until the first section shall have been tested successfully.

C. Final Acceptance:

1. Prior to final inspection all pipelines shall be flushed and cleaned and all debris removed. Before storm drain lines are accepted, all lines shall be tested for leakage as specified herein and inspected for line and grade by checking each section between manholes for alignment. A full circle of light shall be seen by looking through the pipe at a light held in the manhole/catch basin at the opposite end of the section of drain line being inspected.
2. Any corrections required in line and grade shall be made at the expense of the Contractor.

2. PRODUCTS

2.1 BEDDING MATERIALS

A. Bedding materials shall conform to Section 02222 - Excavating, Backfilling and Compacting for Utilities.

2.2 GENERAL REQUIREMENTS FOR PIPE MATERIAL

A. Pipe material shall conform with Section 02610 - Pipe and Fittings and as shown on the Drawings.

2.3 MANHOLES

A. Manholes shall conform to Section 02584 - Manholes and as shown on the Drawings.

2.4 FRAME AND GRATE FOR MANHOLES

A. Frames and grates for manholes shall conform to Section 02584 - Manholes and as shown on the Drawings.

3. EXECUTION

3.1 INSTALLATION

A. Conform with COS Standard Specifications Section 7-17.3, Construction Requirements and the Drawings.

B. Perform deflection test on flexible pipes in accordance with Specification 02610 - Pipes and Fittings.

C. Install manholes in accordance with Section 02584 - Manholes.

* * * END OF SECTION * * *

SECTION 02731

FORCEMAINS

1. GENERAL

1.1 DESCRIPTION OF WORK

A. This section includes installation of all new forcemains.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Section 01300: Submittal Procedures.

B. Section 02150: Shoring.

C. Section 02222: Excavating, Backfilling and Compacting for Utilities.

D. Section 02610: Pipe and Fittings.

E. Section 02760: Existing Utilities/Facilities Underground and Overhead.

1.3 REFERENCE

A. City of Seattle (COS) Standard Specification Sections referenced in this specification shall be the 2011edition of the COS Standard Specifications for Road, Bridge and Municipal Construction, unless otherwise noted.

1.4 SUBMITTALS

A. Procedure: Conform to Specification Section 01300 - Submittal Procedures.

1.5 QUALITY ASSURANCE

A. Applicable Standards

1. Construction and material quality standards for this Section shall be as described in the COS Standard Specifications for Road, Bridge and Municipal Construction, 2011 Edition; Divisions 7 and 9.
2. Construction standards for this Section shall be as shown in the COS Standard Plans for Municipal Construction, 2011 Edition.

B. Testing Before Acceptance:

1. The Owner may require that the first section of pipe, not less than 300 feet in length, installed by each of the Contractor's crews be tested in order to qualify the crew and/or the materials.

2. Pipe laying shall not be continued more than an additional 300 feet until the first section shall have been tested successfully.
3. The Contractor shall perform pipe pressure testing per COS Standard Specification Section 7-11.3(11), Hydrostatic Pressure Test.

C. Final Acceptance:
1. Prior to final inspection all pipelines shall be flushed and cleaned and all debris removed, and hydrostatically tested.
2. All lines shall be tested for leakage.
3. Any corrections required shall be made at the expense of the Contractor and the line retested.

2. PRODUCTS

2.1 PIPE MATERIALS

A. Pipe materials shall conform to Section 02610 - Pipes and Fittings.

2.2 BEDDING MATERIALS

A. Bedding materials shall conform to Section 02222 - Excavating, Backfilling and Compacting for Utilities.

3. EXECUTION

3.1 SURVEY LINE AND GRADE

A. Field survey: Conform with Section 02020 – Field Surveying.

B. The Contractor shall transfer line and grade and control his work.

C. The Contractor may control his line and grade by the use of approved surveying instruments operated by qualified personnel.

D. The Contractor shall constantly check line and grade of the pipe and in the event they do not meet specified limits, the work shall be immediately stopped, the Owner and Engineer notified, and the cause remedied before proceeding with the work.

3.2 BEDDING

A. Proper preparation of foundation, placement of foundation material where required, and placement of bedding material shall precede the installation of all pipe. This shall include the necessary preparation of the native trench bottom and/or the top of the foundation material as well as placement and compaction of required bedding material to a uniform grade.

3.3 STORM SEWER FORCEMAIN

A. Storm Sewer forcemain pressure piping shall be constructed and tested in conformance with COS Standard Specification Section 7-11.3, Construction Requirements; except that disinfection will not be required.

3.4 REPAIRS

A. Any pipe or appurtenance which has been laid or jointed that is not in conformance with the Contract Documents shall be repaired or be removed and replaced at the expense of the Contractor.

B. Repair bands or clamps or concrete collars shall not be used to repair defective pipe.

* * * END OF SECTION * * *

SECTION 02760

EXISTING UTILITIES/FACILITIES UNDERGROUND AND OVERHEAD

1. GENERAL

1.1 RELATED WORK SPECIFIED ELSEWHERE

A. Section 02221: Excavating, Backfilling and Compacting for Structures.

B. Section 02222: Excavating, Backfilling and Compacting for Utilities.

C. Section 03485: Precast Concrete Vaults.

1.2 LEGAL REQUIREMENTS-UNDERGROUND FACILITIES

A. The Contractor shall, before commencing excavation in any area, comply with the provisions of any applicable laws relating to or governing the identification, location, marking, and responsibility for protecting and repairing of underground facilities.

B. Whenever there may be a conflict between the provisions of any law and the provisions of these specifications, the provisions of law shall control.

1.3 DEFINITIONS

A. Utility means any facility or item placed above or below ground for use in connection with the storage or conveyance of water, sewage, electronic, telephonic or telegraphic communication, cablevision, electric energy, petroleum products, gas, gaseous vapors, hazardous liquids, or other substances and including, but not limited to pipes, sewers, conduits, cables, valves, lines, wires, manholes, and attachments.

B. Pipe zone is defined as extending from the bottom of the required excavation to twelve (12) inches over the top of the pipe.

1.4 IDENTIFICATION

A. All underground utilities known by the Owner to be in the proposed area of excavation are identified on the Drawings.

B. The underground utilities identified on the Drawings have not and cannot be precisely located by the Owner or its agents and location is approximate only because such information is within the control of the owners of the underground utilities. The Engineer, under this Contract, does not warrant the location of underground utilities.

C. Other overhead utility lines are generally not shown on the Drawings.

1.5 NOTIFICATION

A. It is the responsibility of the Contractor to give notice to the Engineer, who will notify the Owner, of any utilities known or suspected to be within the area of any proposed excavation or construction activities.

B. The Contractor is responsible to have the locations of underground utilities marked by the utility owners prior to beginning excavation.

C. The Contractor is responsible for determining the extent of any hazard created by electrical power in all areas and shall follow procedures during construction as required by law and regulation. Prior to construction, the Contractor shall meet with utility owners and determine the extent of hazards and remedial measures and shall take whatever precautions may be required.

D. The Contractor's attention is directed to Federal, State, and local safety codes relative to limitations of work in proximity to overhead power lines.

1.6 QUALITY ASSURANCE

A. The Contractor will be required to have available a pipe finder and personnel capable in its use and to utilize same to satisfy himself/herself as to the exact location of such underground facilities in the interest of avoiding unnecessary damage, maintenance costs, and to insure continuity of customer service.

B. Contractors shall cooperate with utility owners to aid in locations and maintenance of existing utilities.

1.7 ELECTRICAL TRANSMISSION AND SERVICE LINES

A. Since the Engineer cannot anticipate the construction methods or techniques and equipment to be used by the Contractor in performing the work, the extent of the possibility of the Contractor's equipment and personnel coming in contact with electrical transmission lines cannot be fully anticipated, and there is no representation that all electrical transmission lines are shown on the Drawings.

B. The Contractor is charged with the responsibility of observing and investigating the presence of any electrical transmission lines which might impinge on his work whether overhead or underground and shall consult with and utilize the information given by utility owners and operators to determine the extent of any hazards and remedial measures required, and follow appropriate safety procedures.

1.8 ABOVE GROUND UTILITIES

A. Existing above ground utilities, whether shown on the Drawings or not, shall be maintained, relocated, rerouted, removed and restored as may be necessary by the Contractor in a manner satisfactory to owners and operators of the utilities.

1.9 UNDERGROUND AND UTILITY SERVICE LATERALS

A. Underground utility service lines, including but not limited to sanitary sewer services, gas services, water services, house or yard drains, and electricity or telephone services shall be maintained, relocated, rerouted, removed and restored by the Contractor with the least possible interference with such services.

1.10 RESTORATION BY UTILITY OWNER

A. The right is reserved by owners of public utilities and franchises to enter upon any street, road, right-of-way, or easement for the purpose of maintaining their property and for making necessary repairs or adjustments caused by the Contractor's operations.

B. The Contractor shall save the Owner harmless of any costs so incurred in restoration of a utility damaged by the Contractor except in special cases outlined above, and subject to the provisions of any law.

1.11 RESTORATION OF DRAINAGE FACILITIES

A. Where it is necessary for drainage facilities to be removed and replaced, existing pipe, manholes and catch basins may be reinstalled when approved by the agency having jurisdiction.

B. The materials shall be cleaned by the Contractor before reinstallation.

C. When it is necessary to replace existing pipe, catch basins, or manholes, the new materials shall be of equal strength and similar design to existing materials and shall meet current standards.

D. Installation shall be in accordance with the applicable provisions of these specifications.

E. All costs, whether new or existing facilities are installed, shall be considered to be included in the unit prices bid for the various items and no additional payment shall be allowed.

* * * END OF SECTION * * *

SECTION 03100

CONCRETE FORMWORK

1. GENERAL

1.1 RELATED WORK SPECIFIED ELSEWHERE

A. Section 01300 Submittal Procedures.

B. Section 03200: Concrete Reinforcement.

C. Section 03251: Anchors and Inserts.

D. Section 03252: Expansion and Contraction Joints.

E. Section 03300: Cast-In-Place Concrete.

1.2 REFERENCE

A. City of Seattle (COS) Standard Specification Sections referenced in this specification shall be the 2011edition of the COS Standard Specifications for Road, Bridge and Municipal Construction, unless otherwise noted.

1.3 QUALITY ASSURANCE

A. Standards:
   1. "Guide to Formwork for Concrete", ACI 347.
   2. "Chapter 19", International Building Code.
   3. U.S. Product Standard PS 1 for Plywood.
   4. Standard Grading and Dressing Rules No. 16 of the West Coast Lumber Inspection Bureau.

1.4 SUBMITTALS

A. Procedure: Conform to Specification Section 01300 - Submittal Procedures.

B. A description of the forming system with complete details. Specify panel width (chord lengths) for circular structures. Illustrate the proposed location of all construction joints, method of securing embedded items and blockout procedures (if proposed).

1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. On delivery to job site, place materials in area protected from weather.

B. Store materials above ground on framework or blocking and cover with protective waterproof covering providing for adequate air circulation or ventilation.

C. Handle materials to prevent damage.

2. PRODUCTS

2.1 MATERIALS

A. Plywood: New or in new condition "B-B Plyform Class 1 Exterior" grade plywood, 5/8 inch minimum thickness.

B. Steel Panels: Flat steel sheet or plate of sufficient thickness, or braced sufficiently, to prevent noticeable deflection from pressure of concrete. Steel forms galvanized and/or coated to prevent rust and staining.

C. Framing, Studding, and Bracing: "Standard" or "Construction" grade West Coast species lumber.

D. Form Ties: Prefabricated rod of the cone-type snap-tie configuration; or approved threaded internal disconnecting type to resist all imposed loads of freshly placed concrete, and permit tightening and spreading of forms. Plastic cone snap-ties shall break back 1 to 1-1/2 inches.

E. Form Coating:
   1. Lacquer, plastic or epoxy coating or non-staining form oil that will not impair the bonding quality for final finish of the painting or protective coating.
   2. Coatings containing mineral oils or other non-drying ingredients are not permitted.

F. Shores and Falsework: Standard patented, manufactured shores, or sound commercial construction lumber.

G. Chamfer Strips: Chamfer strips (for all exposed edges) 3/4 inch, 45° bevel wood strips or reusable plastic triangular strips.

3. EXECUTION

3.1 DESIGN OF FORMWORK

A. Design formwork to safely support vertical and lateral loads which might be applied until such loads can be supported by the concrete structure. Carry vertical and lateral loads by formwork system to ground or to in-place construction which has attained adequate strength for that purpose.

B. Design forms and falsework to include assumed values of live load, dead load, weight of moving equipment operated on formwork, concrete mix, height of concrete drop, vibrator frequency, ambient temperature, foundation pressures, stresses, lateral stability, and other factors pertinent to safety of structure during construction.

C. Provide shores and struts with positive means of adjustment capable of taking up formwork settlement during concrete placing operations, using wedges or jacks or a combination thereof. Provide trussed supports when adequate foundations for shores and struts cannot be secured.

D. Form facing materials shall be supported by structural members spaced to prevent deflection. Design camber in formwork as required for anticipated deflections.

E. Design formwork to be readily removable without impact, shock, or damage to cast-in-place concrete surfaces and adjacent material.

F. Keep oil or other agents from getting on reinforcing steel, embedded items, or other surfaces requiring bond with concrete.

3.2 LAYOUT OF FORMWORK

A. Locate and stake out all forms and establish all lines and levels and elevations.

3.3 CONSTRUCTION OF FORMS

A. Formwork - General:
1. Before concrete is placed in any form, verify horizontal and vertical form position and correct all inaccuracies. Complete all wedging and bracing in advance of placing of concrete.
2. When setting form ties, leave no metal to remain in wall closer than one inch from surface. Ties shall fit tight to prevent mortar leakage at holes in forms. Ties shall be protected from rusting at all times. No wire ties or wood spreaders are permitted. Cutting ties back from concrete face is not permitted.
3. At construction joints, anchor forms by using an adequate number of form ties in the new pour a few inches from the construction joints. Do not rely on ties adjacent to the joint used in previous placements.
4. For exposed concrete, forms shall be of new plywood, metal panel, or approved panel materials, smooth, and continuous.
5. For unexposed concrete, forms shall be plywood, metal, boards, or approved material. Boards: nominal one inch minimum thickness, sound and tight, commercial construction lumber, shiplapped or tongue-and-grooved, dressed on at least one side and both edges for tight fit. Plywood, metal, or approved material equal to or better than board surface.

B. Camber: Forms for slabs cambered unless otherwise noted.

C. Chamfered Corners: All corners chamfered 3/4 inch, unless shown otherwise on the Drawings. Provide 45-degree triangular moldings in forms for all chamfering required.

D. Inspection and Cleanout Openings: Provide inspection and cleanout openings at the bottom of all forms for walls over 8 feet in height and for forms for irregularly shaped placement where cleaning and inspection from the top would be impractical.

E. Coordination: Coordinate the installation of all items to be inserted or embedded in concrete. Support all items to maintain accurate alignment and prevent distortion during concrete placement.

F. Cleaning: All dirt, chips, sawdust, mud, water and other foreign matter shall be removed from within the forms or within the excavated areas before any concrete is deposited therein.

3.4 NOTIFICATION AND OBSERVATION

A. Prior to placing of any concrete, and after placement of reinforcing steel in the forms, notify the Engineer at least 24 hours in advance of placing concrete to permit observation.

3.5 DEFECTIVE WORK

A. Any form movement or deflection during construction or finished surface variations in excess of the tolerances specified will be basis for rejection of cast-in-place product and requirement for replacement of same.

3.6 REMOVAL OF FORMS

A. Do not remove forms and supports until concrete has attained sufficient strength to support anticipated loads.

B. The listing below serves only as a guide in determining the minimum length of time required before removal of forms and is based on the use of Type I Portland Cement. When high early strength Portland Cement is used, the length of time listed below may be reduced to not less than one-third time listed, but not less than 1 day.

1.	Walls in mass work	24 hours
2.	Thin walls (12 inches or less) and sides of beams and girders	48 hours
3.	Columns	7 days
	Bottom forms and supports of slabs	14 days

C. Use methods of form removal which does not cause overstressing of the concrete. Remove supports to permit the concrete to uniformly and gradually take the stress due to its own weight. Do not use high impact methods to remove supports.

D. Break back ties after concrete has cured sufficiently to maintain unbroken bond with steel rod.

3.7 REUSE OF FORMS

A. Any reused form for exposed concrete work shall be reconditioned to "like new" condition. Any reused form shall be cleaned, repaired, and recoated before each reuse.

3.8 BLOCKOUTS

A. Where pipes, castings, or conduits pass through the walls, place such pipes or castings in the forms before pouring the concrete, or in special cases, with the express consent of the Engineer or as specified, build accepted boxes in the forms to make cored openings for subsequent insertion of such pipes, castings or conduits. Provide boxes or cores with continuous keyways and waterstop all the way around, and with slight flare to facilitate grouting and the escape of entrained air during grouting.

* * * END OF SECTION * * *

SECTION 03200

CONCRETE REINFORCEMENT

1. GENERAL

1.1 RELATED WORK SPECIFIED ELSEWHERE

A. Section 01300: Submittal Procedures.

B. Section 03100: Concrete Formwork.

C. Section 03300: Cast-In-Place Concrete.

1.2 REFERENCE

A. City of Seattle (COS) Standard Specification Sections referenced in this specification shall be the 2011edition of the COS Standard Specifications for Road, Bridge and Municipal Construction, unless otherwise noted.

1.3 QUALITY ASSURANCE CONTROL

A. Manual of Standard Practice for Detailing Reinforced Concrete Structures, ACI 315.

B. Manual of Standard Practice, Concrete Reinforcing Steel Institute.

1.4 SUBMITTALS

A. Procedure: Conform to Specification Section 01300 - Submittal Procedures.

B. Placing drawings, bending and cutsheet schedules shall be submitted to the Engineer for review.

C. Mill test reports for each shipment of reinforcement shall be submitted to the Engineer for review.

1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Deliver reinforcement to project site in bundles marked to coordinate with placement drawings.

B. Handle and store to prevent contamination from dirt, oil and other materials which will affect bond.

C. Store a minimum of 6" above ground and in locations where the materials are not be subject to abuse.

2. PRODUCTS

2.1 MATERIALS

A. Reinforcing Bars: Unless specified otherwise, deformed bars meeting requirements of ASTM A615, Grade 60.

B. Welded Wire Fabric: Wire mesh shall meet requirements ASTM A185, "Welded Steel Wire Fabric for Concrete Reinforcement".

C. Tie Wire: Steel, black annealed, 16-gauge minimum.

D. Reinforcing Bar Supports: Per CRSI Manual Chapter 3, pregalvanized or plastic-coated.

E. Welded Reinforcing Bars: Welded Reinforcing Bars shall meet requirements ASTM A706.

3. EXECUTION

3.1 INSTALLATION

A. Placement and Tolerances: Conform to CRSI "Manual of Standard Practice".

B. Splices:
1. Do not splice bars except at locations shown or noted on the Drawings or as otherwise approved by the Engineer.
2. Tie lap slices securely with wire to prevent displacement of splice during placement of concrete.
3. Perform welded splices in accordance with ACI Building Code (ACI 318).
4. Lap wire fabric one full mesh minimum and tie with wire.

C. Cleaning: Remove dirt, grease, oil, loose mill scale, excessive rust, and foreign matter that may reduce bond with concrete.

D. Protection During Concreting: Keep reinforcing in proper position during concrete placement.

E. Concrete Cover: Maintain minimum concrete cover over reinforcement as specified in ACI 318 or as noted.

* * * END OF SECTION * * *

SECTION 03251

ANCHORS AND INSERTS

1. GENERAL

1.1 RELATED WORK SPECIFIED ELSEWHERE

A. Section 01300: Submittal Procedures.

B. Section 03100: Concrete Formwork.

C. Section 03300: Cast-In-Place Concrete.

1.2 REFERENCE

A. City of Seattle (COS) Standard Specification Sections referenced in this specification shall be the 2011edition of the COS Standard Specifications for Road, Bridge and Municipal Construction, unless otherwise noted.

1.3 SUBMITTALS

A. Procedure: Conform to Specification Section 01300 - Submittal Procedures.

B. Shop drawings for all anchors, inserts and embedded products (wall castings, pipes with seep rings, and special castings).

1.4 QUALITY ASSURANCE

A. Use only materials compatible with embedded concrete environment.

1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Deliver and store all items to be embedded in a manner to prevent damage or contamination.

2. PRODUCTS

2.1 MATERIALS

A. Anchor Rods: ASTM F1554, Grade 36, Steel unless otherwise noted.

B. Threaded or Slotted Inserts: Galvanized malleable iron or stainless steel size and type as specified.

C. Adhesive Anchors: HILTI HIT-RE 500-SD Epoxy Anchoring System.

D. Expansion Anchors: HILTI Kwik Bolt TZ Expansion Anchors or approval equal.

3. EXECUTION

3.1 INSTALLATION

A. Coordinate the location and placement of all items to be embedded in concrete, including with respect to reinforcing steel.

B. Coat any embedded aluminum with asphalt paint.

3.2 EMBEDDING

A. Set accurately and hold in position all embedded products during placement until the concrete is set.

B. Use templates to accurately set anchor rods within AISC tolerances.

3.3 DRILLED IN GROUTED ANCHORS

A. In lieu of embedding anchor bolts, it may be acceptable to drill holes in hardened concrete and install the anchor bolts with special mortars when approved by the Engineer. Use a carbide-tipped bit with a drill set in roto-hammer mode. Bonding mortar shall be adhesive or epoxy grout type. Install per manufacturer’s instructions as amended by current ICC Evaluation Service Report. Studs of equal size and embedment may be substituted for anchor bolts if nut fasteners are used. Drilled in studs or anchors utilizing mechanical expansion locking in any process areas shall not be used.

* * * END OF SECTION * * *

SECTION 03252

EXPANSION AND CONTRACTION JOINTS

1. GENERAL

1.1 RELATED WORK SPECIFIED ELSEWHERE

A. Section 01300: Submittal Procedures.

B. Section 03100: Concrete Formwork.

C. Section 03300: Cast-In-Place Concrete.

1.2 REFERENCE

A. City of Seattle (COS) Standard Specification Sections referenced in this specification shall be the 2011edition of the COS Standard Specifications for Road, Bridge and Municipal Construction, unless otherwise noted.

1.3 SUBMITTALS

A. Procedure: Conform to Specification Section 01300 - Submittal Procedures.

B. Sealant type and manufacturer.

C. Premolded composition board and backer rod samples.

D. Certification of conformance to Specifications.

1.4 QUALITY ASSURANCE CONTROL

A. Prepare and use in strict accordance with manufacturer's instructions. Discard materials after specified "shelf life".

B. Deliver products in manufacturer labeled containers with complete preprinted instructions by manufacturer included.

C. Installers experienced in use of products.

2. PRODUCTS

2.1 MATERIALS

A. Preformed board shall conform to Federal Specification HH-F-341, Type I, Class B (moderately resilient) unless otherwise noted.

B. Joint Sealant:

1. Polyurethane material designated for bonding to concrete for service, which when cured, develops a high bond between surfaces and provides flexible watertight seal, non-sag, resistant to mild alkalis and acids, oils and meets all requirements for Federal Specifications TT-S-00230, Type II, Class A.
2. Prior to ordering the sealant, submit to the Engineer for review, sufficient data to show experience record of sealant and general compliance with the Specification requirements.
3. Joint primer supplied by the same manufacturer supplying the sealant.

C. Backer-Rod: Closed cell polyethylene backer-rod shall be used in sealant joints. The backer-rod shall be resilient and of a diameter at least 1/8 inch larger than the groove and shall be approved by the sealant manufacturer.

3. EXECUTION

3.1 INSTALLATION

A. Joints constructed and located as shown on the Drawings or as approved by the Engineer.

B. Sealant Surfaces: Clean, free of oil, grease, residue and other foreign materials, prior to application of sealant in accordance with manufacturer's recommendations. Prime all joints with joint primer.

C. Sealant Application:

1. Tape or otherwise protect surfaces adjacent to joints not intended to receive sealants. The backer rod shall be accurately placed in the joint to provide the depth of sealant called for on the Drawings or as directed by the Engineer.
2. Neatly apply sealants to fill void required to level non-sag surface. Maintain uniform application procedures to continuously apply sealant. Complete joint system without intermediate stops and starts.
3. Sealant shall be applied according to manufacturer's recommendations in a manner so as to avoid entrainment of air in the joint. All sealant shall cure at least seven (7) days before the structure is filled with water.
4. Secure preformed board to surfaces with fasteners and procedures recommended by the manufacturer.

* * * END OF SECTION * * *

SECTION 03300

CAST-IN-PLACE CONCRETE

1. GENERAL

1.1 RELATED WORK SPECIFIED ELSEWHERE

A. Section 01300: Submittal Procedures.

B. Section 03100: Concrete Formwork.

C. Section 03200: Concrete Reinforcement.

D. Section 03251: Anchors and Inserts.

E. Section 03252: Expansion and Contraction Joints.

1.2 REFERENCE

A. City of Seattle (COS) Standard Specification Sections referenced in this specification shall be the 2011edition of the COS Standard Specifications for Road, Bridge and Municipal Construction, unless otherwise noted.

1.3 SUBMITTALS

A. Procedure: Conform to Specification Section 01300 - Submittal Procedures.

B. Concrete mix design (for each concrete type used) by an independent laboratory, including strength tests of four (4) cylinders proportioned to mix design formula.

C. Certification of quality of all concrete, mortar, and grout mix design ingredients including admixtures with supporting test data, mill quality control results and all information specified and requested by the Engineer.

D. Qualifications of Quality Assurance Control personnel responsible for concrete consistency, strength, air content and all testing.

E. Curing materials and methods proposed with certification statements of materials quality.

F. Test results, in approved format, at specified intervals for all field sampling and specimens.

G. Certification of quality and type of epoxy bonding materials.

H. Trip tickets for each load of concrete, grout or mortar indicating weights of all materials and additives used in the batch.

I. Location of construction joints not shown on the Drawings.

1.4 QUALITY ASSURANCE

A. Delivery: Furnish a certificate with each truckload of concrete product delivered to the site, indicating the composition and quality of the mix. Include size and weight of each aggregate, amount of cement, amount of water and amount and kind of any additives included in the concrete, grout fill, or mortar.

B. Standards: All applicable standards of the following:
   1. American Concrete Institute - ACI
   2. Concrete Reinforcing Steel Institute - CRSI
   3. International Building Code - IBC
   4. Other local codes or criteria noted on the Drawings.

C. Concrete Consistency:
   1. Test each truckload of concrete for slump at point of placement. Calibrate each mixer or haul unit to be used by measuring slump near the beginning and near the end of the discharge cycle. Mix units determined by the Inspector or Engineer to be deficient in mixing capability shall not be used in subsequent deliveries. Slump testing procedures per ASTM C143.
   2. Consistency per values below with tolerance of $\pm$ 1 inch.
      a. 2-3 inches slump for structural elements 12 inches and greater in thickness.
      b. 2-4 inches slump for structural elements less than 12 inches in thickness.

D. Concrete Test Cylinders:
   1. Prepare a minimum of four (4) test cylinders for each location (slab, wall, foundation, etc.) for each day’s placement or each 50 cubic yard, whichever is greater.
   2. Test set of four (4) cylinders as follows:
      a. One at 7 days.
      b. One at 14 days or as required.
      c. Two at 28 days.
   3. Prepare and test cylinders per ASTM C31 and C39.

E. Prior to placement have available at placement location all tools, cylinder molds, slump cone, rod, curing containers and all other apparatus required for sampling and testing.

F. Air Entrained: One test for each mix design.

G. Grout: Prepare and cure three samples of each batch of grout for compression test per ASTM C109, one at 7 days, two at 28 days.

1.5 STORAGE OF MATERIALS

A. Maintain in continuously clean environment and in manner required to maintain homogeneity.

B. Cements, grouts, and mortar containerized and kept in dry humidity environment. Engineer or Inspector shall reject materials which have hardened or show any evidence of initial hydration.

2. . PRODUCTS

2.1 CONCRETE

A. ASTM C94 with mix design approved by the Engineer.

B. Compression strength and water cement ratio: The minimum compressive strength and cement content of concrete shall be not less than that shown in the tabulation that follows. The Engineer may order the cement content for any class of concrete to be increased over the quantity specified in the tabulation if it is determined that such increase is necessary to attain the required strength. Such increased quantities of cement, if so ordered, shall be furnished by the Contractor at no additional cost to the Owner.

Class of Concrete Min. 28-day Compr. Strength (psi)	Type of Work	Max. Size Aggregate (in.)	Min. Cement Pounds (Per Cu.Yd.)	Max. W/C Ratio
4,000	Walls, foundations, and slabs on grade unless noted otherwise	1-1/2	564	0.45
3,000	Cradles, thrust blocks, encasements and all other uses	1-1/2	517	0.45

C. Cement ASTM C150:
   1. Type I or II.

D. Aggregates:
   1. Conform to ASTM C33.
   2. Maximum wear 50% at 500 revolutions, AASHTO T96.
   3. Select aggregate size to be compatible with formwork clearances, rebar clearances and slab thickness per ACI 318 Section 3.3.2.

E. Water:
   1. Clear and free from injurious amounts of oil, acid, salt, alkali, organic matter, or other deleterious substances.

F. Admixtures:
1. Use only those specified in approved mix design.
2. Air entrain all concrete unless elsewhere excepted, with agent conforming to ASTM C260. Freshwater concrete air content between 4% and 6% by volume.
3. Apply in strict accordance with manufacturer's printed instructions.
4. No chloride contents permitted.
5. Compatible with coatings specified elsewhere.

2.2 AGGREGATE FOR MORTAR

A. Conform to 2.1 except gradation as follows:

Sieve Size Square Opening	Percent Passing By Weight
No. 4	95 - 100
No. 8	80 - 90
No. 16	55 - 87
No. 30	30 - 60
No. 50	12 - 30
No. 100	0 - 10

2.3 GROUT

A. For equipment use nonshrink, nonstaining, premixed grout. Mix in accordance with the manufacturer's directions.

B. For Fill: Driest consistency practical composed of 1 part Portland Cement 3 parts sand (by volume). Aggregate proportions may be varied slightly to give the most workable mix.

C. For placement at base of walls, one part fine aggregate, one part cement. In a thick cream consistency.

D. Perform mixing, surface preparation, handling, placing, consolidation, curing and other means of execution per the written recommendations of the manufacturer.

2.4 CURING MATERIALS

A. Polyethylene Sheeting 0.004 inch thick.

B. Waterproof Paper: Polyethylene-coated, Fed. Spec. UU-B-790 Type I, Grades A, B, C, Style 4. Define lap control lines clearly by printed markings.

C. For all of the grade slabs, the Contractor shall supply and install a curing compound which shall serve as a surface sealer. Submit products to the Engineer for approval. See Section 3.4C.

3. EXECUTION

3.1 MIXING AND TRANSPORTATION

A. Ready-Mixed Concrete: Conform to ASTM C94 for Truck Mixed Concrete.

3.2 PLACING

A. Deliver only in sufficient quantities required for specified time interval use and placement. Discard concrete having initial set before placement. Remixing with water or supplementing with other materials is not permitted once initial set has occurred. Initial set as evidenced by typical hydration characteristics to be determined by the Engineer.

B. Place as nearly as possible to final position to avoid segregation of the materials and displacement of reinforcement. Placement shall be completed within 30 minutes after water is first added to the mix. However, at the discretion of the Inspector if climatic and temperature conditions are suitable and when the concrete is continually agitated, the time may be extended to 1-1/2 hours.

C. Place no concrete in the absence of the Engineer.

D. Do not change consistency (slump) for a given placement without the written permission of the Engineer.

E. Keep open trough and chutes of steel or steel lined, clean and free from coatings of hardened concrete.

F. Do not drop concrete a distance of more than 5 feet unless approved in writing by the Engineer.

G. Do not place concrete in horizontal members or sections until the concrete in the supporting vertical members or sections has been consolidated and a 2-hour period has elapsed since placement in the vertical member to permit shrinkage to occur.

H. In walls containing door and window openings, hold up placements at the top and bottom of the openings. Stop other placements at levels to conform to the Drawing details.

I. Layout and sequence of placing of concrete in monolithic structures as shown on the Drawings or approved by the Engineer.

J. Within a placement, deposit concrete in horizontal layers not to exceed 18 inches in depth. Place at rate such that: (1) no concrete surface shall obtain initial set before additional concrete is placed on it and (2) yielding of forms is not so great as to cause the concrete surfaces to exceed the tolerances specified.

K. Unless specified otherwise, place all slabs and finished floors to finish elevation in one continuous operation, except that the Contractor may place a separate finish topping if prior approval is received from the Engineer. Floor slab sectional thicknesses shown are minimum thicknesses. Slopes on floors increase, rather than decrease, slab thicknesses.

L. Where a separate finish topping is placed, decrease structural slab thickness by the maximum thickness of the finish topping and maintain finished floor elevation as noted on the Drawings.

M. Construction Joints:
1. Locate construction joints as shown on the Drawings or as approved by the Engineer.
2. Locate construction joints so as not to impair the strength of the structure, and only at locations shown on the Drawings or approved by the Engineer.
3. Construct bulkheads to neatly fit reinforcement and waterstops and prevent concrete leakage.
4. Provide waterstops or sealants in construction joints where required.
5. Unless shown otherwise, key all construction joints.
6. Continue reinforcement through construction joint unless otherwise shown or noted.
7. Before placing concrete against previously placed concrete, thoroughly roughen and clean by wet sandblasting or green cutting with an air-water jet.
    a. Use air-water cutting at the proper time after the initial set. Use a high pressure air-water jet to expose clean, sound aggregate without undercutting the edges of the larger aggregate. Protect adjacent subgrade when cutting is used on slab edges.
    b. After cutting or sandblasting, rinse the surface until wash water contains no cloudiness. Dispose of wastes from cutting, washing and rinsing so they do not stain or abrade exposed surfaces.
8. Place concrete continuously to a predetermined construction joint.

N. Care shall be taken in placing concrete through reinforcement so that no segregation of the coarse aggregate occurs. On the bottom of slabs where the congestion of steel near the forms makes placing difficult, a layer of mortar, of the same strength as used in concrete, shall first be deposited in the forms, followed immediately by the concrete. The thickness and use of this mortar layer shall be as approved by the Engineer.

O. Special care shall be taken to prevent splashing forms or reinforcement with concrete. Any hardened concrete or partially hardened concrete on the forms or reinforcements above the level of the concrete already in place shall be removed before proceeding with the work.

P. Cold Weather Placement:

1. Concrete shall be placed only when the temperature is at least 40° F, and rising, unless permission to pour is obtained from the Engineer.
2. Material shall be heated and otherwise prepared so that batching and mixing can proceed in full accord with the provisions of this Specification.
3. Suitable means shall be provided for maintaining the concrete at a temperature of at least 50°F for a period of at least the first five (5) days and at a temperature above freezing for the remainder of the specified curing period, except that where high-early-strength cement is used, this period may be reduced to 72 hours. The methods proposed for heating the materials and protecting the concrete shall be approved by the Engineer.
4. Salt, chemicals, or other materials shall not be mixed with the concrete for the purpose of preventing freezing. Accelerating agents shall not be used.

Q. Hot Weather Placement:
1. The temperature of fresh concrete at the time of placement during hot weather shall be a maximum of 90° F to prevent an accelerated setting of the concrete.
2. A retarding densifier admixture shall be used when the high expected atmospheric temperature for the day is 85°F or above. Admixture shall be used in accordance with the manufacturer's recommendations.

R. Placing Concrete Against Earth:
1. Unless otherwise called for on the Drawings, earth cuts shall not be used as forms for vertical surfaces without the prior approval of the Engineer.
2. Concrete placed on or against earth shall be placed only upon or against firm, damp surfaces free from frost, ice and standing or running water. Concrete shall not be placed upon mud, or upon fills until the required compaction has been obtained.

S. Placing Concrete Slabs:
1. Smooth subgrade surface irregularity with thin film of masonry sand prior to placing vapor barrier.
2. Place vapor barrier on subgrade in maximum widths commercially available (if vapor barrier is required). Longitudinal laps 6 inch minimum. End laps 2 feet minimum.
3. Edge and side laps to be in continuous contact. Place materials to maintain tight lap contact.
4. Repair any tears in the material.
5. Place concrete without displacing vapor barrier.
6. Vapor Barrier: when used on locations indicated on the Drawings, the vapor barrier shall be fungus-resistant when tested by the method set forth in Federal Specifications L-S-125, shall have a vapor permeance rating not exceeding 0.5 permeability rating as determined by methods set forth in ASTM Standard E-96-66, Procedure E. It shall conform to U.S. Department of Commerce Standard CS-238-61, not less than 0.006-inch nominal thickness.

T. Depositing Concrete in Water:
1. Concrete may be deposited in water only when specifically authorized.
2. Methods and equipment used shall be acceptable to the Engineer.
3. When deposited by the tremie method, the tremie shall be watertight and sufficiently large to permit a free flow of concrete. The discharge end shall be kept submerged continuously in the concrete and the shaft kept full of concrete to a point well above the water surface. Placing shall proceed without interruption until the top of the concrete has been brought to the required height.

3.3 COMPACTING

A. Compact all concrete with high frequency internal vibrators immediately after placing.

B. Use external vibrators for compacting concrete where the concrete is inaccessible for adequate compaction by internal vibrators; construct forms sufficiently rigid to resist displacement or damage from external vibration.

C. Penetrate concrete with a sufficient number of vibrations immediately after it is deposited. Move vibrator throughout the mass so as to thoroughly work the concrete around reinforcement and embedded fixtures and into corners and form recesses. Vibrate the minimum time required to compact the concrete in place and not cause separation of the materials. Concrete shall be compacted to maximum density as determined by tests for yield. Select vibrator size to efficiently accommodate reinforcement clearances.

3.4 CURING AND PROTECTION

A. General:
1. Maintain at site ready to install, before actual concrete placing begins, all equipment and materials needed for optimum concrete curing and protection; maintain extra vibrators on standby in case of malfunction of any unit.
2. Protect finished surfaces or edges from stains, abrasions and breakage during the entire construction period.
3. Protect all concrete from accelerated drying and excessive heat at all times. Close all galleries, conduits and other formed openings through the concrete during the entire curing period and as long thereafter as practicable to prevent drying of concrete by air circulation.
4. Install slab curing covers immediately after initial set or as soon as free water has disappeared from the surface of the concrete after finishing or surfacing.

B. Water Curing (Preferred):
1. Use water curing specified herein for concrete placement.

2. Keep concrete continuously wet by covering with burlap or an approved material utilizing a system of perforated pipes or mechanical sprinklers or other approved methods. (Periodic wetting acceptable.)
3. Keep forms wet at all times to prevent opening of joints and the drying out of the concrete.
4. Water for curing shall be clean and free from any elements which might cause objectionable staining or discoloration of the concrete.
5. Cover surfaces completely with sheeting. Where a single sheet does not cover the entire surface, lap ends and edges at least 4 inches and continuously seal with tape or other suitable means recommended by the manufacturer.
6. Continue waterproof sheet curing for 7 days. Maintain sheeting and edge and end seals intact for entire period. Repair immediately any breaks in the sheeting envelope.

C. Curing Compounds (Use only when specifically approved and for optimum climatic conditions):
1. Do not use curing compounds unless their use is authorized in writing by the Engineer. Curing compounds unacceptable where concrete is exposed to the direct rays of the sun or accelerated drying conditions.
2. Curing compounds shall not be used unless their use is face membrane type and shall be applied in accordance with the manufacturer's recommendations. They shall be of such composition and characteristics as will spread readily on moist concrete and deposit a hard, tenacious film without permanently coloring the concrete surfaces that shall be exposed. The resultant film shall adhere to the concrete surface without chemical reaction therewith, and shall not peel. Maintain coverage for 28 days to prevent detrimental loss of water from the concrete.
3. Prior to applying curing compounds to formed surfaces, the surfaces shall be moistened with a spray of water immediately after forms are removed. Moistening shall be continued until the surfaces will not readily absorb more water. The compound shall be applied as soon as the moisture film has disappeared and while the surface is still damp.
4. On unformed surfaces, the compounds shall be applied immediately after finishing and after bleeding water and "shine" has disappeared.
5. Curing compounds shall not be used on surfaces where future bonding, painting or protective coating is required. In cold weather, curing compounds shall not be used on concrete surfaces that are kept at curing temperature by the use of steam.

3.5 REPAIRING CONCRETE

A. Immediately after removal of forms, break back all form ties and inspect concrete surfaces for defects. Complete repair of defects within 48 hours after removal of forms. No repairs shall be made until the defects have been reviewed and method of repair approved by the Engineer.

B. Remove all defective or damaged concrete, including honeycombed, sand streaked, or fractured material from the area to be repaired. Chip out areas to one inch minimum depth. Edge shall be squared with the surface to eliminate feather edges.

C. Before placing the repair material obtain Engineer inspection. Clean area free of chipping dust, dried mortar, and all other foreign materials.

D. Keep surfaces to be repaired continuously wet for at least three hours prior to placing new concrete or mortar. No free water on the surface when the repair material is placed.

E. Apply a bonding agent to the area to be repaired before placing repair material. Apply the bonding agent per manufacturer's published instructions attached to container.

F. For all repair surfaces permanently exposed to atmosphere use white cement in proportions found by trial to be effective in producing a color that, in the hardened patch, matches the surrounding concrete surface.

G. Make repairs or patch form tie holes by (1) dry-packing, (2) filling with concrete, or (3) plastering with mortar or a combination of all 3 in conformance with the following:

1. Use the dry-pack method for holes at least one inch deep where the depth is equal to, or greater than the smallest surface dimension of the defect, such as cone-bolt or form tie holes, and for narrow slots cut for the repair of cracks. Do not use the dry-pack method where lateral restraint cannot be obtained. Place and pack dry-pack mortar in layers having a compacted thickness of approximately 3/8 inch. Solidly compact each layer over its entire surface by use of a hardwood stick and hammer. Do not use metal tools for compacting. Compact surface just flush with adjacent area. Do not use steel finishing tools or water to facilitate finishing.
2. Use concrete replacement for (1) holes extending entirely through concrete sections; (2) for holes larger than one square foot and deeper than four inches in which no reinforcement is encountered; (3) for holes larger than one square foot where reinforcement is exposed. Concrete used for replacement shall be of the same strength and mixture as used in the structure except for color matching as specified above.
3. Use mortar replacement for holes too wide to dry-pack and too shallow for concrete replacement and when approved by the Engineer for other conditions not covered above.

H. Cure all repairs with the same methods as new concrete.

3.6 CONCRETE FINISHES AND TOLERANCE

A. General Finish:

1. Finish concrete surfaces to conform with the following table unless otherwise noted on the Drawings.
2. Formed Surfaces System

Exterior - Exposed and One Foot Below	F4
Exterior - Below Grade	F2
Interior	F3

3. Slabs

Tops of exterior footings in contact with soil or backfill	U2
Exterior - Except as Otherwise Noted	U5

B. Formed Surfaces: Finishes for formed surfaces shall be as designated below:

1. Finishing for F1 and F2 finishes consists of concrete repairing only, which is to be completed within 48 hours after forms are removed.
2. Finishing for F3 and F4 finishes shall immediately follow concrete repairing and be completed within 96 hours after the forms are removed. Except where forms are left in place for the duration of the curing period, finishing shall be done during the curing period, keeping the interruptions to the curing process as short as possible. Where forms left on prevent finishing during the curing period, finishing shall be completed within 48 hours after forms are removed. All finishes shall receive a minimum of 24 hours of curing after completion of the finish. Curing shall be carefully done so as not to disturb or remove any of the mortar.
3. Finish F1: Rough formed surface with defective concrete repaired and form tie holes and other holes over 2 inch deep filled. Forms may be built with a minimum of refinement and form sheathing may be any material that will not leak mortar or yield beyond specified tolerances when the concrete is vibrated.
4. Finish F2: Smooth, formed concrete surface with all fins, projections and loose material removed and defective concrete and form tie holes and other holes over 2 inch deep, repaired and filled. Forms in contact with concrete shall be plywood or steel.
5. Finish F3: Smooth, formed concrete surface with all fins, projections and loose material removed, and defective concrete, form tie holes, air bubble holes, surface pits, holes from defective forms, nailhead holes and similar surface defects, repaired and filled. Forms in contact with concrete shall be plywood or steel. Form construction shall be planned so that if any pattern from the forms is left in the concrete surface it will harmonize with the structure or building. All joints shall be horizontal or vertical.
6. Finish F4: Exceptionally smooth, formed concrete surface with all fins, joint marks, bulges, projections and loose material removed. Sandblast to expose air bubble holes, surface pits and similar minor surface defects. Defective concrete, form tie holes, holes from defective forms, and other

holes too large to fill by "sack rubbing" shall be repaired and filled. Finish with sack rubbing as follows.

a. Thoroughly wet the surface and begin treatment while the concrete is still damp. Use 1 part cement, 2 parts (by volume) of sand which will pass a No. 16 screen, and enough water so that mortar consistency will be that of thick cream. Rub mortar thoroughly over the area with clean burlap or a cork or sponge rubber float to fill all pits, surface holes and air bubble holes. While the mortar in the pits is still plastic, rub the surface with a dry mix of mortar. This dry rub shall remove all excess mortar and place enough dry material in the pits to stiffen and solidify the mortar flush with the surface. No material shall remain on the surface except that within the pits. When the ambient temperature is 85° F or higher, keep the mortar continuously damp by means of a fog spray for 24 hours during the setting period. Take care that the fog spray does not remove any of the mortar. Break finish for any area only at natural breaks in the finished surface.

b. Rub all surfaces that are to be finish painted with a carborundum stone to provide a smooth texture and to remove any latent material on the surface. Pre-blast walls to remove any residual form oils prior to finishing when walls are to be finish painted.

c. Form requirements shall be the same as Finish F-3.

C. Unformed Surfaces:

1. Working on unformed surfaces in various finishing operations shall be held to the minimum required to produce the desired finish. Use of any finishing tool in areas where water has accumulated will not be allowed. Work in these areas shall be delayed until the water has been absorbed, has evaporated, or has been removed by draining, mopping, dragging off with a loop of hose, or by other means. In no case, shall cement or mixture of cement and sand be spread on the surface to absorb excess moisture nor shall such materials or water be added to facilitate troweling. Joints and edges, unless specified otherwise, shall be carefully finished with edging tools.

2. Finishes for unformed surfaces shall be as designated below:

a. <u>Finish U1</u>: Even, uniform finish. Consolidate level and screed concrete to obtain an even, uniform surface. Surplus concrete shall be removed immediately after consolidation by striking it off with a sawing motion of the straight edge or template across wood or metal strips that have been set as guides. When the surface is curbed use screed strips at approved intervals. For long, narrow stretches of curved surfaces such as on invert paving, a heavy slip form may be used. In the case of extensive flat paving, a paving and finishing machine is preferred.

b. Finish U2: A wood float finish. Follow treatment specified for finish U1 by floating either by hand, or by power driven equipment. Floating to be started after some stiffening has taken place in the surface concrete and the moisture or "shine" has disappeared. Work the concrete no more than necessary to produce a surface known as "wood float finish" which is uniform in texture and free of screed marks. Do any necessary cutting and filling during the floating operations.

c. Finish U3: A steel troweled finish. Follow the treatment specified for the finish U2, except leave a small amount of mortar without excess water at the surface to permit effective troweling. Start steel troweling after the moisture film or "shine" has disappeared from the float surface and after the concrete has hardened enough to prevent an excess of fine material and water from being worked to the surface. Trowel with firm pressure that will flatten the sand surface left by the floating and produce a dense, uniform surface free of blemishes, ripples and trowel marks.

d. Finish U4: A hard, steel troweled finish burnished. Follow the treatment specified for finish U3 with additional steel troweling after the surface has nearly hardened, using firm pressure and troweling until the surface has a burnished appearance.

e. Finish U5: Broom finish. Follow the treatment specified for finish U3 by roughening the surface immediately after troweling with a fiber bristle broom in a direction perpendicular to the direction of traffic. Broom grooves not more than 1/16 inch deep. After brooming, neatly tool all joints and edges to configuration.

f. Finish U6: Anti-slip finish. Follow the treatment specified for finish U3 and immediately after troweling, dust 30 to 40 lbs. or regular non-slip aluminum oxide 14/36 grit abrasive grain uniformly over each 100 sq. ft. of area. Trowel the grit into the surface and after troweling, brush with a fiber bristle broom in a direction perpendicular to the direction of traffic. Broom grooves not more than 1/16" deep. After brooming neatly tool all joints and edges to configuration.

D. Tolerances:

1. Unless otherwise required, allowable tolerances for concrete surfaces shall be in accordance with those shown in the table below. Surface irregularities are classified as either "abrupt" or "gradual". Offsets caused by displaced or misplaced form sheathing, lining, or form section or by defective form lumber shall be considered as abrupt irregularities. All others are classed as gradual irregularities. Gradual irregularities shall be measured with a template consisting of a straight edge for plane surfaces and its equivalent for curved surfaces.
2. The length of the template for testing formed surfaces shall be 5 feet. The length of the template for unformed surfaces shall be 10 feet. Maintain a 5 foot length and 10 foot length steel template on the job site.

3. Maximum allowable irregularities in concrete:

Finish Designation	Irregularity in Inches Gradual	Abrupt
F1	1	2
F2	2	1/4
F3	1/4	3/16
F4	3/16	3/16
U1 thru U6	1/8	1/8

3.7 TESTING AND REPAIRING CONCRETE STRUCTURES

A. Testing & Inspection:
   1. Separately test each individual chamber that will contain liquid by filling to the overflow with water after the 28-day design strength of the concrete has been obtained. Repair any visible leakage. Damp spots that do not run may be acceptable if below ground or not on walls.
   2. Allowable leakage not to exceed 0.1% of the volume contained in the chamber in a 24 hour period. Leakage in excess of the allowable amount requires repair to reduce leakage and will be considered to lack watertightness.
   3. The Owner will employ the service of an independent testing laboratory for taking of tests and to conduct inspection services. Cooperate with the testing laboratory and provide storage for shipping boxes, cylinder molds and assist in storage of shipping of cylinders.

B. Repairs:
   1. In the event that the structure is not watertight, outline a procedure for repair prior to proceeding with the repair work. Complete any repairs to new work as per specifications at Contractor expense.
   2. Approved repairs can include, but not necessarily be limited to one or a combination of the repairs listed below. Use of these techniques is not to be construed as a warranty by the Engineer that the methods outlined will satisfy leakage repair requirements:
      a. Replace defective concrete.
      b. Grouting of the joint by drilling grout holes to the center of the structural unit and forcing grout into the joint under pressure.
      c. Cutting of a bevel groove on the pressure side of the joint. Groove 2 to 3/4 inch in width and depth caulked with epoxy joint sealer in accordance with the manufacturer's instructions.

3.8 UNSATISFACTORY CONCRETE

A. Any concrete placed which fails to meet or exceed the specified strength requirements as determined from molded cylinders or cores, or to meet the density or surface requirements, or which has been frozen during placing or curing, shall be removed and replaced with satisfactory materials at the Contractor's expense.

B. Method of determining unsatisfactory concrete: Visual appearance characteristic of rain or freeze damage to concrete which is apparent to the Engineer.

* * * END OF SECTION * * *

SECTION 03485

PRECAST CONCRETE VAULTS

1. GENERAL

1.1 DESCRIPTION OF WORK

A. This section covers furnishing and installation of the precast concrete vaults and wetwell.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A.	Section 01300:	Submittal Procedures.
B.	Section 02221:	Excavating, Backfilling and Compacting for Structures.
C.	Section 02222:	Excavating, Backfilling and Compacting for Utilities.
D.	Section 02240:	Dewatering.
E.	Section 02584:	Manholes.
F.	Section 02610:	Pipes and Fittings.
G.	Section 02720:	Storm Drainage.
H.	Section 03300:	Cast-in-Place Concrete.

1.3 REFERENCE

A. City of Seattle (COS) Standard Specification Sections referenced in this specification shall be the 2011edition of the COS Standard Specifications for Road, Bridge and Municipal Construction, unless otherwise noted.

1.4 SUBMITTALS

A. Procedure: Conform to Specification Section 01300 - Submittal Procedures.

1.5 ADAPTATION OF PRODUCT

A. Furnish product readily adaptable for installation and operation in the manner shown on the Drawings.

1.6 SITE CONDITIONS

A. A review of previous geotechnical investigations near the vaults and wetwell location was performed and the findings of the review are presented in a technical memorandum titled, "Review of Geotechnical Reports, North Boeing Field, dated April 21, 2001." This memorandum is provided as Appendix A of this specification. Geotechnical investigation reports referenced in the memorandum are available upon request from the Owner.

2. PRODUCTS

2.1 GENERAL

A. The vaults and wetwell shall be precast as manufactured by Utility Vault Co. or approved equivalent, and modified to meet the requirements of the Drawings.

2.2 SHOULDER BALLAST

A. Shoulder Ballast: COS Standard Specification Section 9-03.9(2).

2.3 GEOTEXTILE

A. Geotextile below the wetwell and vaults shall meet the requirements for geotextile for soil stabilization in accordance with COS Standard Specification Section 9-37, Table 3.

2.4 WETWELL DESIGN

A. Conform to ASTM C913 and ACI-318.

B. Design for AASHTO HS-20 loading.

C. Soil unit weights provided in Table 1 shall be used for the wetwell. Allowable bearing pressure of 1,000 pounds per square foot (psf) shall be used. This value may be increased by one-third for dead plus short term live loads, such as wind and seismic.

D. Vertical soil surcharge pressure of 0 psf shall be used for the wetwell.

E. Lateral earth pressures used for design of the wetwell shall be assumed to increase linearly with depth, per the concept of an equivalent fluid. The unit weight of the equivalent fluid shall be estimated by multiplying the total unit weight of soil by the appropriate earth pressure coefficient, presented in Tables 1. For rigid precast structures an at-rest pressure condition is appropriate, while for deformable shoring an active earth pressure condition is considered to be appropriate. A minimum factor of safety of 1.5 shall be applied to the passive earth pressure coefficient.

F. Below the estimated groundwater table, at approximately 9 feet below the existing ground surface, hydrostatic pressure – also assumed to increase with depth – shall be added to the multiplication of the buoyant unit weight of the soil and appropriate earth pressure coefficient.

Table 1: Soil Parameters for Wetwell

Material	Depth below Existing Ground Surface (ft.)	Unit Weight (pcf)	Friction Angle (deg)	Active Earth Pressure Coefficient (K_a)	At-rest Earth Pressure Coefficient (K_0)	Passive Earth Pressure Coefficient (K_p)
Imported Structural Fill (SM/SP)		125	38	0.22	0.38	10.74
Sand to Silty Sand (SP/SM)	0 to 4.5	115	28	0.36	0.53	2.77
Silt to Clayey Silt (ML)	4.5 to 7.5	115	24*	0.42	0.59	2.37
Silty Sand to Sand (SM/SP)	7.5 to 15.0	120	28	0.36	0.53	2.77

Note: * Equivalent effective friction angle for silt for drained conditions.

G. The lateral pressure due to the surcharge load is estimated by multiplying the vertical surcharge pressure by the appropriate earth pressure coefficient. The vertical surcharge pressure is assumed to stay uniform with depth.

H. Conservative earth pressure coefficients and the unit weight are recommended owing to the variability of known soil conditions in the general vicinity.

2.5 ACCESS DOORS

A. This subsection describes materials and installation of the access doors for each wetwell and vault entrance. Number of doors that will be used for each structure are shown on the Drawings.

B. The manufacturer shall guarantee the access doors against defects for a period of five (5) years.

C. Submit catalog cuts or detail drawings and designs of all items specified.

D. Provide access hatch assembly (doors) manufactured by the L.W. Hatch Company, Bothell, Washington or Bilco Company, New Haven, Connecticut as specified for the wetwell and vaults.

1. Channel Frame. The channel frame shall be 1/4-inch aluminum with an anchor flange around the perimeter.

2. Door Leaf. The door leaf shall be 1/4-inch aluminum diamond pattern plate reinforced to withstand AASHTO HS-20 wheel loading. For all double and triple leaf door combinations, the ladder side door shall open first.
3. Drain Coupling. Provide a 1 x 1-1/2 inch aluminum drainage half coupling located as shown on the Drawings.
4. Equipment. Doors shall be equipped with:
   a. 316 Stainless Steel:
      1) Lifting mechanism housing.
      2) Automatic hold-open arm and cover release.
      3) Pins.
      4) Slam lock and spoon handle.
      5) Release handle.
   b. Corrosion resistant stainless steel lifting spring.
   c. Neoprene gasket.
   d. Red vinyl grip on the release handle.
5. Frame Finish. The exterior of the frame that will be in contact with concrete shall have a mill finish with a minimum ten (10) mil dry film thickness holiday-free coating of Koppers Bitumastic 50. The coated surface shall be covered with ten (10) mil thick pressure-sensitive tape to protect it from damage during installation.
6. Hardware. Use only 316 stainless steel hardware.
7. Mill Finish. Provide mill finish on all aluminum surfaces.
8. Padlock Hasp. Provide an aluminum recessed padlock hasp with an aluminum cover.
9. Warning Signs. Furnish a warning sign on the underside of the access door adjacent to hold-open latch, reading:

> 1. DANGER, MAKE SURE “HOLD-OPEN LATCH” IS ENGAGED BEFORE USING.
> 2. CONFINED ENTRY REQUIRED – APPROVED SAFETY DEVICE MUST BE UTILIZED.

3. EXECUTION

3.1 INSTALLATION

A. Wetwell and vault installations shall be as detailed on the Drawings. Precast sections with damaged joint surfaces or with cracks or damage that would permit infiltration shall not be installed.

B. Material at vaults and wetwell subgrade level shall be compacted in place to 95 percent of the maximum dry density as measured using ASTM D1557. The moisture content of the material shall be within 3 percent of the optimum value.

C. If zones of softened soil are encountered in the vault and wetwell subgrade, they shall be replaced with imported structural fill that is compacted to at least 95 percent of the maximum dry density as measured using ASTM D1557.

D. Place the vault and wetwell above compacted shoulder ballast. Shoulder ballast material shall be placed in layers of not more than 6-inches thickness, at moisture content within three percent (3%) of optimum and compacted to a minimum density of 90% of the maximum dry density per ASTM D1557. Compacted shoulder ballast thicknesses below the vault and wetwell shall be minimum 1 foot.

E. Geotextile shall be placed below the shoulder ballast layer.

F. Precast riser sections and top slabs shall be set using the specified joint sealant or gasket. Priming and preparation of surfaces and installation of jointing material shall be in strict accordance with the manufacturer's instructions.

G. Install vault, wetwell and accessories in conformance with the Drawings, Specifications and recommendations of the manufacturer unless otherwise instructed in writing by the Engineer.

H. The joints, pipeline, and conduit penetrations through walls as shown on the Drawings shall be sealed watertight. No leakage will be allowed into the vault and wetwell.

I. Lift holes shall be thoroughly wetted and then be completely filled with mortar, smoothed and pointed both inside and out to ensure water tightness. Steel loops shall be removed and covered with mortar, smoothed and pointed.

J. Provide flexible joint at a distance from the face of the wetwell or vault of not more than 1-1/2 times the nominal pipe diameter or 12 inches, whichever is greater, for all rigid pipes entering or leaving the wetwell or vault.

K. Provide a watertight joint where flexible conduits pass through the wetwell or vault wall by utilizing a sand collar manhole entry coupling that is mortared into the wall. Pipe connection into entry coupling shall be sealed with a rubber ring.

* * * END OF SECTION * * *

APPENDIX A

(TO SECTION 03485 - PRECAST CONCRETE VAULTS)

REVIEW OF GEOTECHNICAL REPORTS, NORTH BOEING FIELD

Technical Memorandum

URS

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To:	Kris Turschmid, PE	**CC:**	Cris Castro, PE Gustavo Franco, PE, SE
From:	Suren Balendra, PE Martin McCabe, PE	**Date:**	April 21, 2011

RE: Review of Geotechnical Reports, North Boeing Field (Job # 33762889)

1. INTRODUCTION

This memorandum presents the geotechnical recommendations for the proposed structures at North Boeing Field. Four structures were identified under this project, Storage/Weir Tanks, Sand Filtration Unit, Control Unit, and Pump Unit. These four structures will be supported by mat foundations. Approximate mat dimensions are as follow:

- Storage/Weir Tanks: 50-foot long by 40-foot wide
- Sand Filtration Unit: 25-foot long by 20-foot wide
- Control Unit: 40-foot long by 20-foot wide
- Pump Unit: 25-foot long by 10-foot wide

2. SUBSURFACE CONDITION

Subsurface conditions and soil characteristics in the vicinity were obtained by reviewing Dames & Moore reports for previous projects nearby, including:

- Dames & Moore, 1990a, Report of Geotechnical Investigation, Proposed Aircraft Painting Facility, Building 3-380, North Boing Field, Job no. 00695-462-016
- Dames & Moore, 1990b, Report of Geotechnical Construction Services, Building 3-369 Addition, North Boing Field, Job no. 00695-467-016

Based on the borings (B-5-89 and B-5-66) in the vicinity of the project area, URS estimated an idealized soil profile at project location as follows:

- 0 to 5.5 feet: Stratum 1 [loose silty SAND (SM)]
- 5.5 to 14 feet: Stratum 2 [soft sandy SILT (ML)]
- Greater than 14 feet: Stratum 3 [loose to medium dense silty SAND/poorly graded SAND (SM/SP)]

Relevant boring logs are provided in Attachment 1.

3. CONCLUSIONS AND RECOMMENDATIONS

3.1 Seismic Design Considerations

The geotechnical-related parameters to be used for seismic design in accordance with the 2009 International Building Code (IBC) provisions are evaluated as described in Section 1613.5 of the IBC. The spectral response accelerations for the "Maximum Considered Earthquake", which has a 2 percent probability of being exceeded in 50 years (i.e. return period of 2500 years), are obtained from the United States Geologic Society (USGS) Earthquake Ground Motion Parameters Version 5.0.9 software corresponding to the site with a latitude of 47.54 degrees and a longitude of –122.32 degrees. The recommended values for Site Class B are:

S_S = 155% g = 1.55 g (short period or 0.2 second spectral response)

S_1 = 53% g = 0.53 g (1.0 second spectral response)

The Site Class is selected using the definitions in Table 1613.5.2 considering the average properties of soils in the upper 100 feet of the soil profile at the site. Information from the previous borings indicates that a Site Class D ("Stiff Soil profile") is the most appropriate for this location. From Table 1613.5.3 the site coefficients F_a and F_v for short period (0.2 second) and 1.0 second are 1.0 and 1.5, respectively.

As discussed below, the site has significant thickness of potentially liquefiable layer. Therefore, the above Site Class and corresponding Site Coefficient values are applicable for structures having fundamental periods of vibration equal to or less than 0.5 second (ASCE/SEI 7-05). Site Coefficient values for structures having fundamental periods of vibration greater than 0.5 second should be determine from a site-response analysis.

Horizontal Peak Ground Acceleration (PGA) of 0.41g was developed based on the 2009 IBC. In the absence of a site specific ground motion study, the PGA is taken as the damped design spectral acceleration value S_{DS} divided by 2.5, as directed in Section 1803.5.12 of the 2009 IBC.

URS used LiquefyPro software (CivilTech Software, 2007) to estimate settlement and the potential for liquefaction. This software employs the empirical procedures outlined in the industry-accepted standard reference (Youd et al., 2001). Fines correction was performed by using Stark/Olson et. al. In this analysis, the fines contents were estimated using the description of the soils on the boring logs.

The analyses were performed using a PGA of 0.41g. The magnitude of the seismic event was taken as M6.6. The results of the liquefaction analyses are presented in Table 1. Graphical results are provided in Attachment 1. The liquefaction analyses indicate that a potentially liquefiable zone generally exists from the depth of groundwater to 35feet below ground surface. Furthermore, isolated zones were also identified as potentially liquefiable below 55 feet as indicated in Table 1.

Table 1-Liquifaction Analyses Results

	Borehole ID	
	B-2-66	**B-5-66**
Total thickness of liquefaction zone (feet)	35	29
Depth of liquefied zone (feet)	9-29, 54.5-56, 67.5-72.5, 93.5-96.7	15-35, 55-60, 64.5-69, 73.5-78.5
Settlement (inches)	6.3	6.9

The total settlement of saturated and unsaturated sands was estimated to be approximately 7 inches, and the differential settlement to be up to 3.5 inches between 20 to 30 feet apart. Liquefaction-induced settlements were estimated by LiquefyPro using the Tokimatsu and Seed (1987) approach.

A cautionary note regarding the results of this analysis is the fact that the empirical method of analysis employed by the LiquefyPro software is applicable only to depths less than about 50 feet. There is no certainty that full liquefaction or any liquefaction will actually occur at depths greater than 50 feet.

The potential for significant “lateral spread” of liquefied soil appears to be low in the vicinity of the project area because neither a “free face” nor “ground slope” condition, as described in Youd, Hansen, and Bartlett (2002) and Bartlett and Youd (1995), is not generally present at this location.

Due to liquefaction, sand is expected to be expelled at the ground surface in “spouts” or “boils” at various, unpredictable locations within areas experiencing liquefaction. This phenomenon may cause uplift and distortion of non-structural floor slabs and pavements.

3.2 Shallow Foundations

Proposed structures can be supported on mat foundations on the existing Stratum 1 with proper subgrade preparation measures, as described herein, are employed. An allowable soil bearing pressure of 500 pounds per square foot (psf) may be used for design of mats if the long-term settlement magnitudes are acceptable for the structures. This value can be increased by one third for transient loads from wind or seismic sources. A minimum embedment depth of 1.5 feet should be used to protect against frost effects.

Footing subgrades in Stratum 1 should be closely inspected for the possible presence of soft or otherwise unsatisfactory soils that may be present. These materials should be removed and replaced with structural fill consisting of sand or sand and gravel with less than about 15 percent fines. Loose zones encountered at the subgrade level in the granular fill soil should be compacted in place to 95 percent of the maximum dry density (MDD) as measured using ASTM D1557. The moisture content of the fill should be within 2 percent of the optimum value.

If zones of softened or Stratum 2 soil are encountered in the footing subgrades, they should be replaced with on-site or imported well graded granular structural fill that is compacted to at least 95 percent of the MDD as measured using ASTM D1557.

In areas that will support structures or slabs and in areas that will receive fill, the exposed surface should be proof-rolled to densify zones of loose granular soil or to help identify very soft zones that may require repair. Proof-rolling of granular soils should consist of at least three complete (back and forth) passes of a heavy (at least 10 ton) vibratory roller. If the exposed subgrade consists of the Stratum 2 soft sandy SILT, the proof-rolling should consist of one pass using a static roller or heavy rubber tire vehicle. If yielding areas are observed, they should be cut to firm bearing soil and filled to grade with structural fill. Filling, if required, can then take place. After cutting is completed, the exposed surface should be compacted and repaired, as described above for areas to receive fill.

Settlement of mat foundations has been estimated using a combination of previous laboratory tests and published correlation. The estimated total long-term settlement of mat foundations are presented in Table 2. Approximately 60 percent of the settlement is expected to occur within 2 to 3 months following application of the full load, with the remainder occurring over a period of approximately 10 years.

Table 2-Long Term Settlement

Footing Dimension	Settlement (inches)	
	Center	Edge
40-foot wide and 50-foot long	2.8	1.6
20-foot wide and 25-foot long	2.4	1.4
10-foot wide and 25-foot long	1.9	1.3
20-foot wide and 40-foot long	2.5	1.5

Note that the settlements described in this section are due to compression of soft soil and are in addition to the liquefaction induced settlements described in Section 3.1.

Because the magnitudes of static and liquefaction settlement estimated above may be too large to be tolerated by the structures, ground improvement in the form of vibro-replacement stone columns or rammed aggregate piers (trade name "Geopiers") can be employed to reduce the magnitude of settlements.

The columns or piers are typically 2 to 3.5 feet in diameter and spaced at 8 to 12 feet. The soft or loose soil is pushed aside by a probe or removed by an auger, and the column/pier is formed by placement of angular gravel compacted into place from the bottom up. The required embedment length of the columns or piers depends on the thickness of vulnerable soils (i.e. either soft or liquefiable materials). At this site the recommended embedment depth is approximately 35 feet, which will fully penetrate the Stratum 2 soft sandy SILT and extend through the variably liquefaction-prone upper 20 feet of the Stratum 3 SAND/silty SAND.

4. LIMITATIONS

The recommendations and descriptions presented in this memorandum are based on soil conditions disclosed by borings drilled during previous geotechnical investigations at the vicinity of the site. The existing subsurface information referred to herein does not constitute a direct or implied warranty that the soil conditions between boring locations can be directly interpolated or extrapolated, or that subsurface conditions and soil variations different from those disclosed by the borings will not be revealed. If, during construction, subsurface conditions different from those described herein are observed, URS should be notified so that such conditions can be reviewed and the recommendations provided herein are revised, as necessary. Similarly, changes to the structure including modified load magnitudes and footing sizes should be brought to the attention of URS so that the potential effect of these changes can be assessed.

5. REFERENCES

Bartlett, S. F. and T. L. Youd. 1995. Empirical Prediction of Liquefaction-Induced Lateral Spread. Journal of Geotechnical Engineering, ASCE, Vol. 121, No. 4.

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Youd, L. T., C.M. Hansen, and S.F. Bartlett. 2002. Revised Multilinear Regression Equations for Prediction of Lateral Spread Displacement. Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 128, No.12.

Youd, T. L., I. M. Idriss, I. Arango, G. Castro, J. T. Christian, R. Dobry, W. D. Liam Finn, L. F. Harder Jr., M. E. Hynes, K. Ishihara, J. P. Koester, S. S. C. Liao, W. F. Marcuson III, G. R. Martin, J. K.

Mitchell, Y. Moriwaki, M. S. Power, P. K. Robertson, R. B. Seed, and K. H. Stokoe II, 2001, Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Workshops on Evaluation of Liquefaction Resistance of Soils, ASCE Journal of Geotechnical and Geoenvironmental Engineering, V. 127, N.10, 2001.

Attachment

1 Calculation Package: Evaluation of Potential for Liquefaction & Estimation of Long Term Settlement.

ATTACHMENT 1

CALCULATION PACKAGE: EVALUATION OF POTENTIAL FOR LIQUEFACTION & ESTIMATION OF LONG TERM SETTLEMENT

URS

1500 Fourth Avenue, Suite 1400
Seattle, Washington 98101
Ph (206) 438 - 2700
Fx (206) 438 - 2699

Calculation Package

Client: Boeing Project No: 33762889

Project: North Boeing Field

Location: Seattle, WA Subject: Foundation Design

Calculation No: 1 Revision: 0 Date: 4/18/2011 Sheet: 1 of 23

Evaluation of potential for liquefaction & Estimation of long term settlement

(Title of Calculations/Document)

STEP 1

	Signature	Date
Methodology & Assumptions Developed By:	Suren Balendra, PE B. Surendran	4/18/2011
Methodology & Assumptions Approved By:	Martin McCabe, PE W. M. McCabe	4/28/11

STEP 2

	Signature	Date
Calculations Completed	Suren Balendra, PE B. Surendran	4/20/11
Calculations Checked	David ~~Johnsonh~~ JOHNSON, E.I.T.	4/28/11

STEP 3

	Signature	Date
Task Manager Approved	Martin McCabe, PE W. M. McCabe	4/28/11
Project Manager Approved	Kris Turschmidt, PE K.T.	5/2/11

COMMENTS

URS

Job: North Boeing Field	Project No. 33762889	Page ____ of ___
Description: Foundation	Computed by: SB	Sheet____ of ____
		Date 4/18/11
______________________________	Checked by:	Date __________

OBJECTIVE:

- Evaluation of potential for liquefaction
- Estimation of long term settlement

INDEX

Item Description **Page**

DATA:

- Site Plan, see pages 3 to 5
- Previous boring logs in the vicinity of the project site , see pages 6 to 12
- Lab test results, see pages 13 and 14

ASSUMPTIONS:

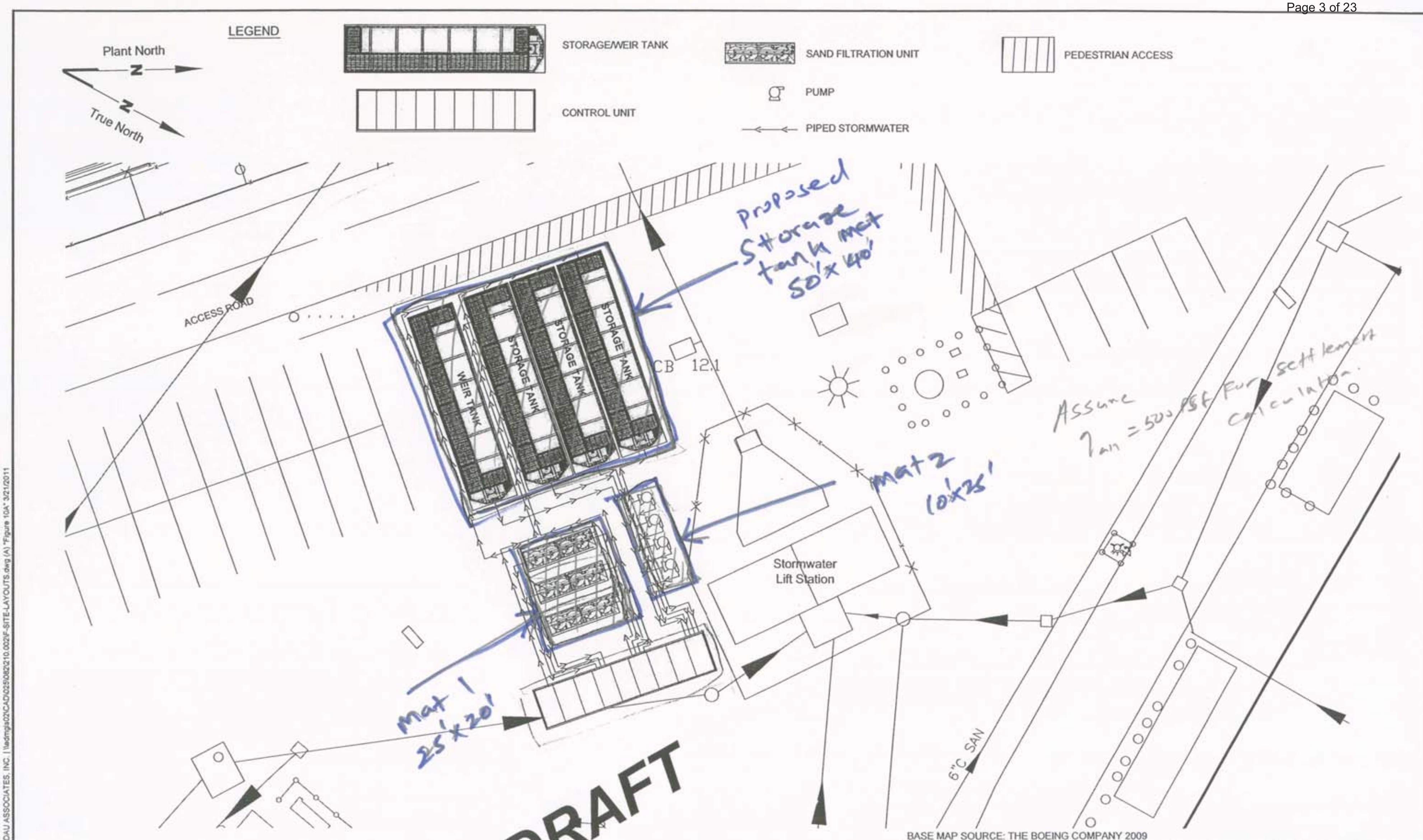
- Water table is 9 ft below ground surface
- Unit weight of the soil =115 pcf
- Hammer efficiency =60%
- Footing embedment=1.5 feet
- E for upper SM=400 ksf
- E for lower SM/SP=600 ksf

APPROACH:

- Use LiquefyPro for evaluation of potential for liquefaction
- Estimate the $C_{C\epsilon}$ using combination of lab and published correlation
- Use UniSettle to estimate long term settlement

REFERENCE:

- Dames & Moore, 1990a, Report of Geotechnical Investigation, Proposed Aircraft Painting Facility, Building 3-380, North Boing Field, Job no. 00695-462-016
- Dames & Moore, 1990b, Report of Geotechnical Construction Services, Building 3-369 Addition, North Boing Field, Job no. 00695-467-016
- Dames & Moore, 1982, Report of Soil Investigation, Proposed Extension to Building 2-08, Plant 2, Job no. 00695-264-05
- 2009 IBC

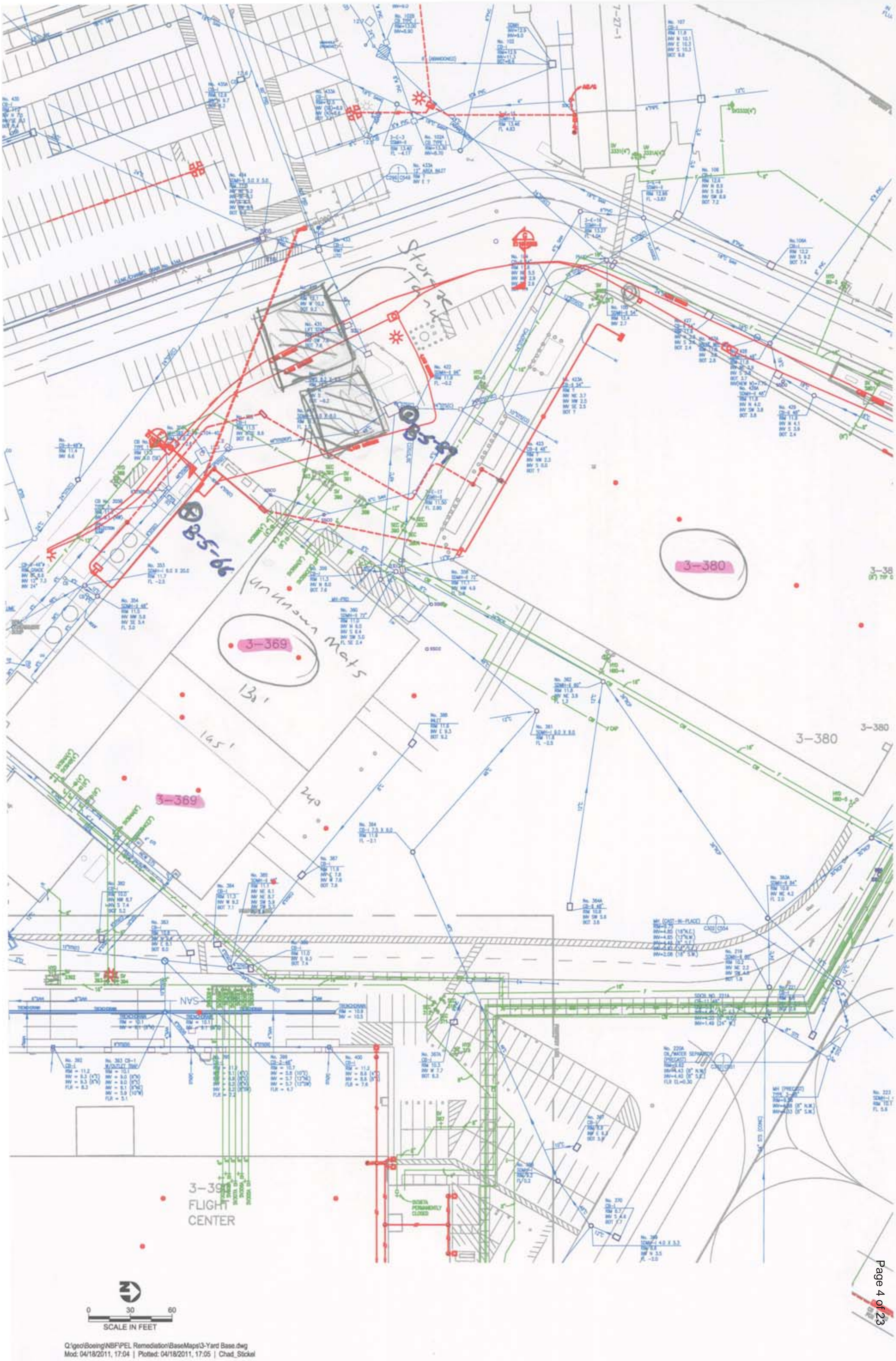


North Boeing Field
Seattle, Washington

LTST System Preliminary Layout, Plan View

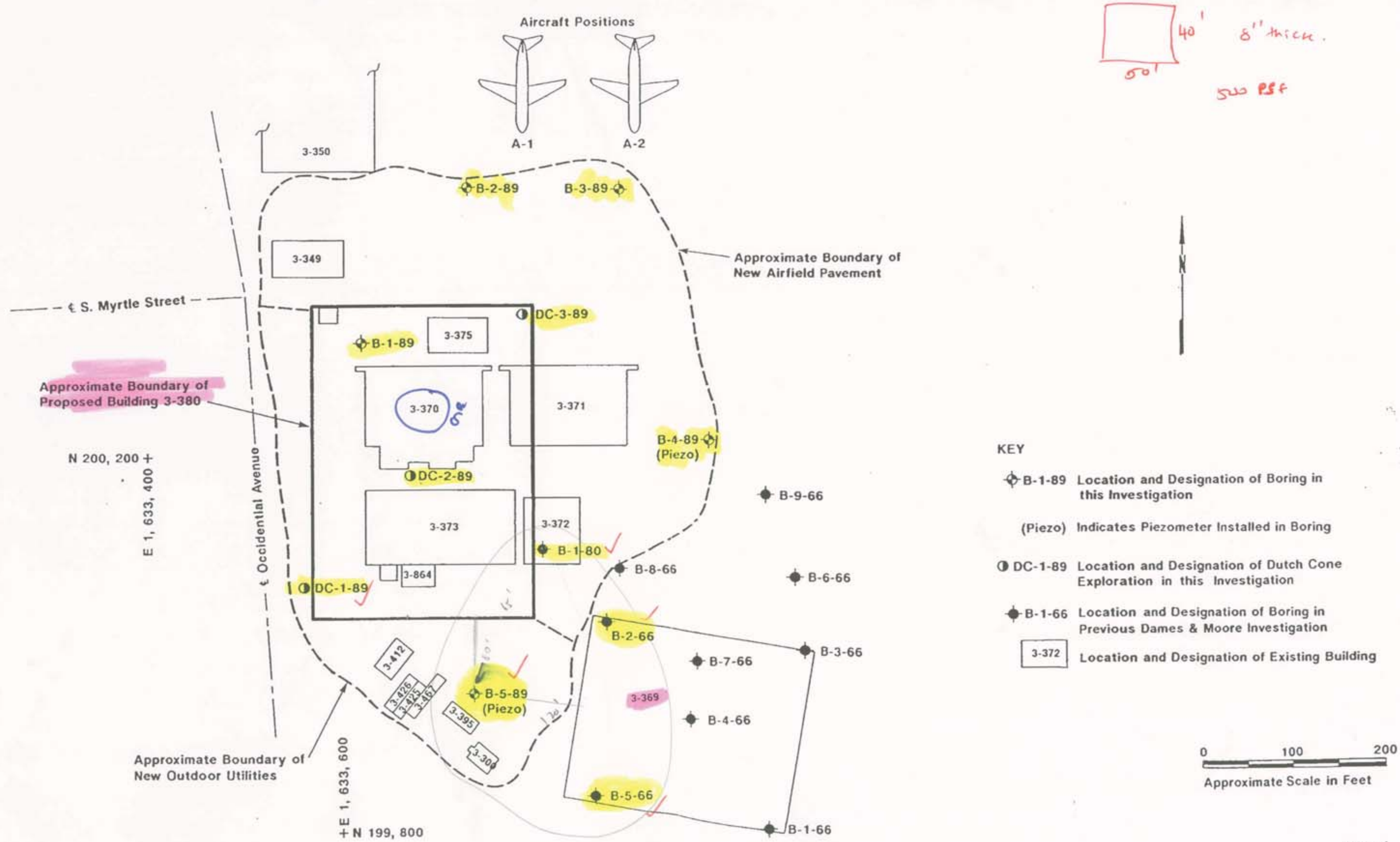
FIGURE 10A

LANDAU ASSOCIATES



Q:\geo\Boeing\NBF\PEL Remediation\BaseMaps\3-Yard Base.dwg
Mod: 04/18/2011, 17:04 | Plotted: 04/18/2011, 17:05 | Chad_Stickel

122954



Reference: Norman Engineering Co. "Site Sketch - Soils and Survey Work" Sheet SK-1, September 28, 1989.

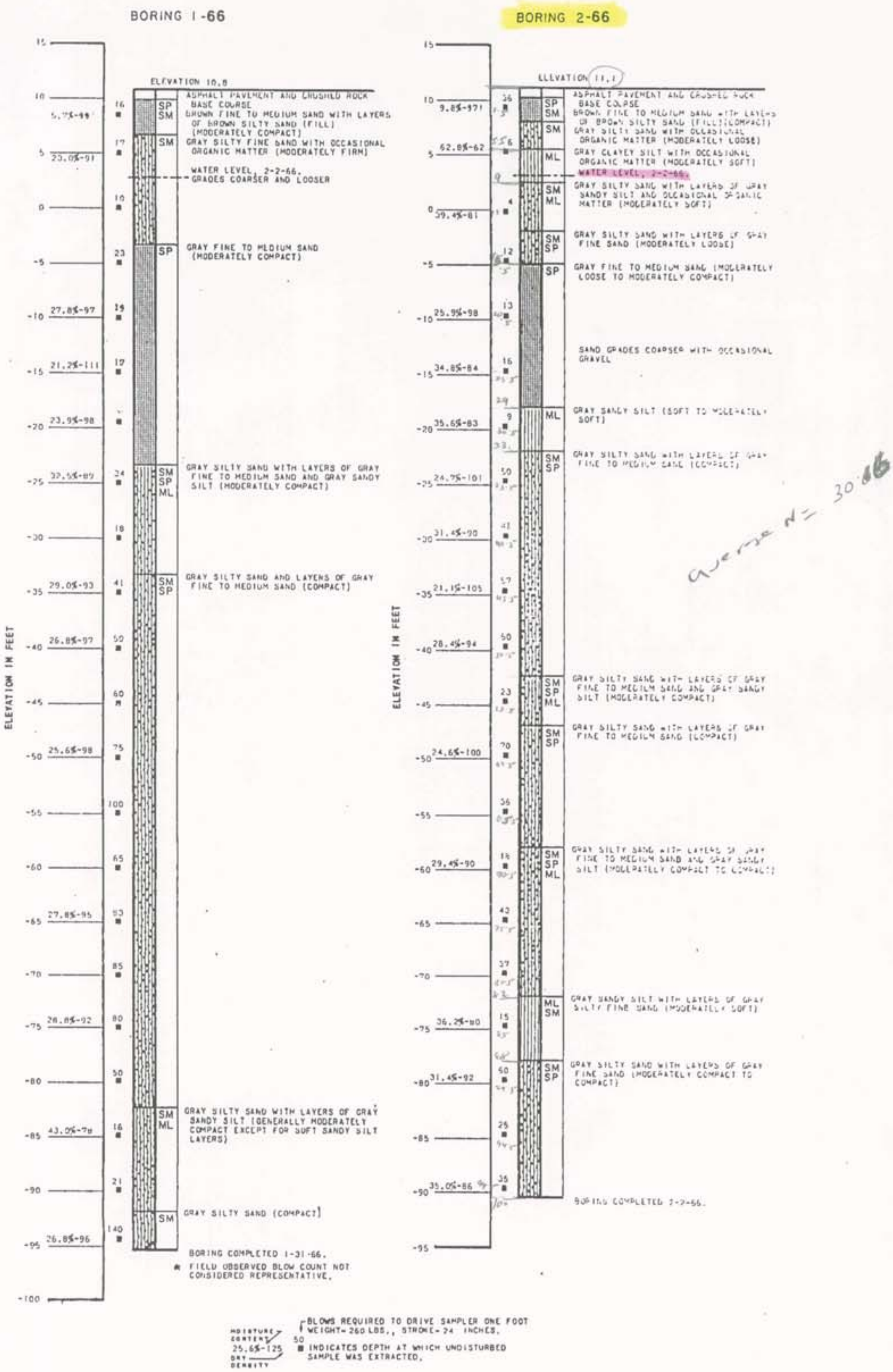
Plate 1

Boring and Dutch Cone Location Plan
Proposed Boeing Aircraft Painting Facility

Dames & Moore

Job No. 00695-462

Job No. 695-467-016



NOTE:
ELEVATIONS REFER TO U.S.C.&G.S. MEAN SEA LEVEL DATUM OF 1929 THROUGH THE MEDIUM OF PACIFIC NORTHWEST SUPPLEMENTARY ADJUSTMENT OF 1947.

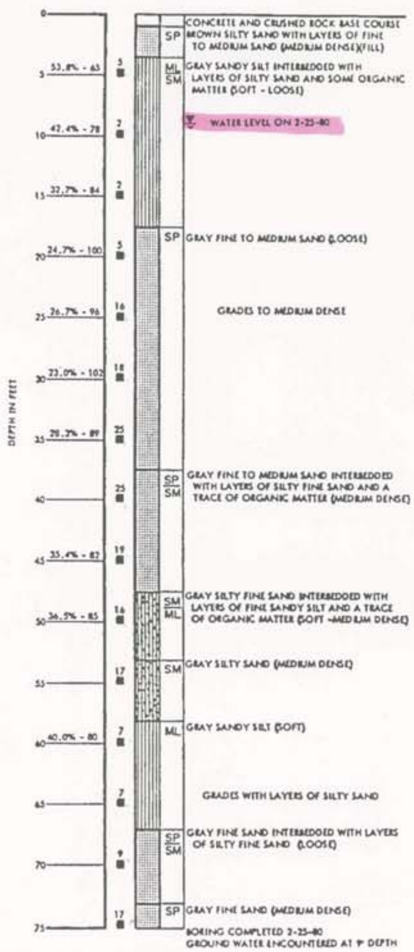
LOG OF BORINGS

Reference: Dames & Moore Report No. 695-102-05, dated March 7, 1966.

Dames & Moore

Plate 2

BORING B-1-80



average N = 12.66

KEY:

MOISTURE CONTENT 42.4% - 78 DRY DENSITY IN PCF

5 — BLOWS REQUIRED TO DRIVE DAMES & MOORE SAMPLER ON FOOT WITH A HAMMER WEIGHT OF 320 LBS., AND A STROKE OF 30 INCHES.

■ INDICATES DEPTH AT WHICH UNDISTURBED SAMPLE WAS EXTRACTED.

NOTE:
THE DISCUSSION IN THE TEXT OF THIS REPORT IS NECESSARY FOR A PROPER UNDERSTANDING OF THE NATURE OF THE SUBSURFACE MATERIALS.

LOG OF BORINGS

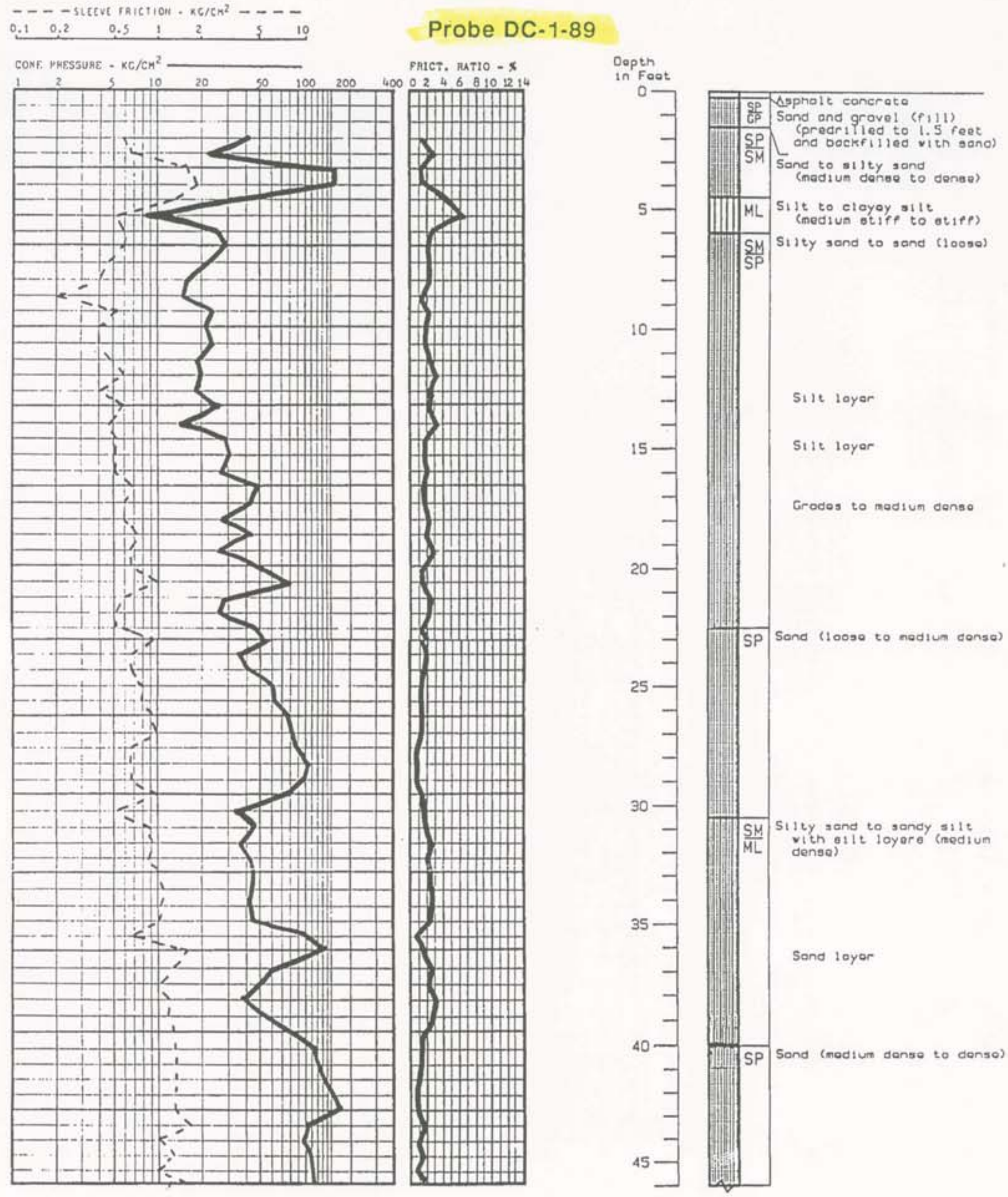
DAMES & MOORE

Plate A-5

Job No. 00695-462-016

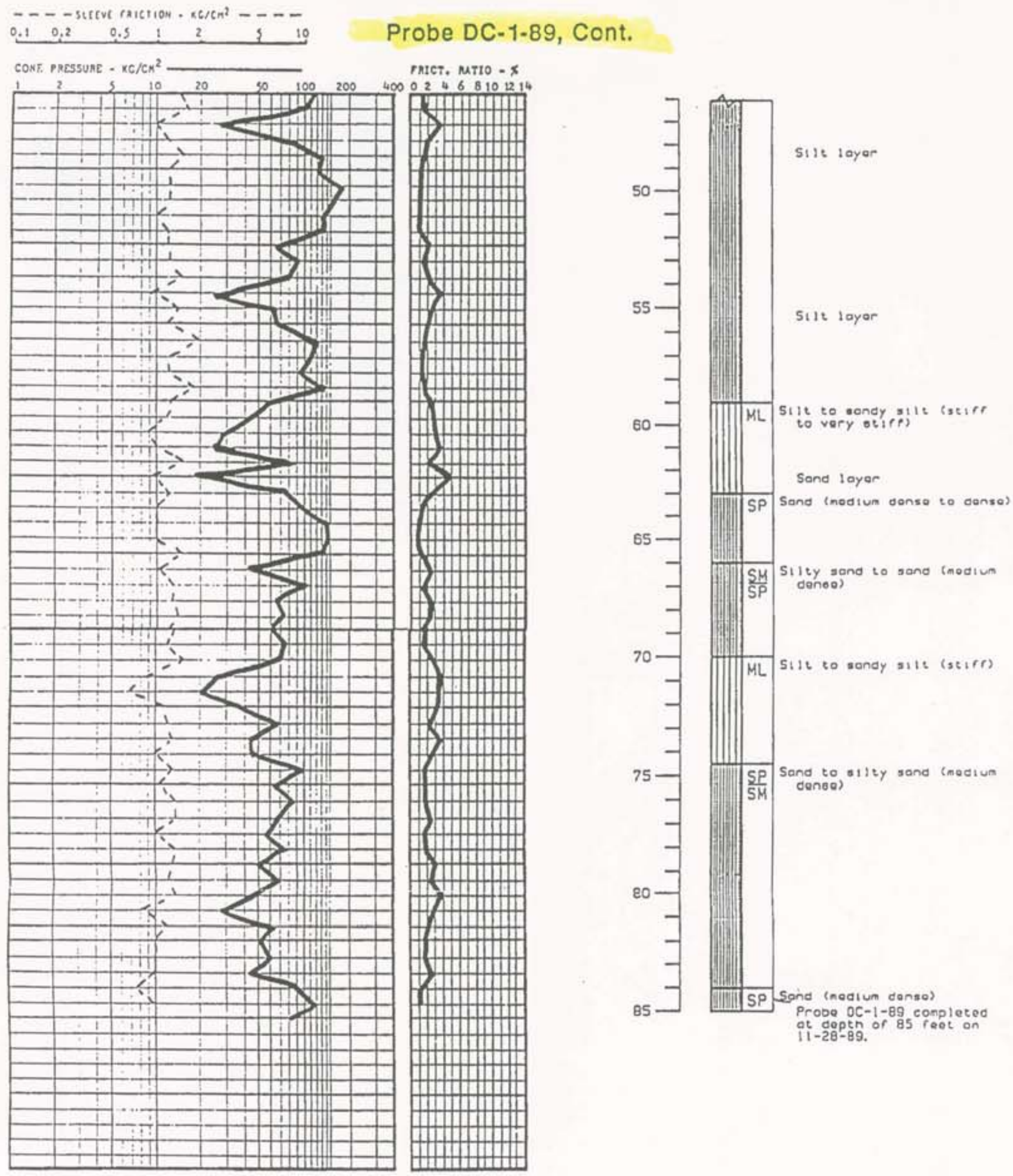
122854

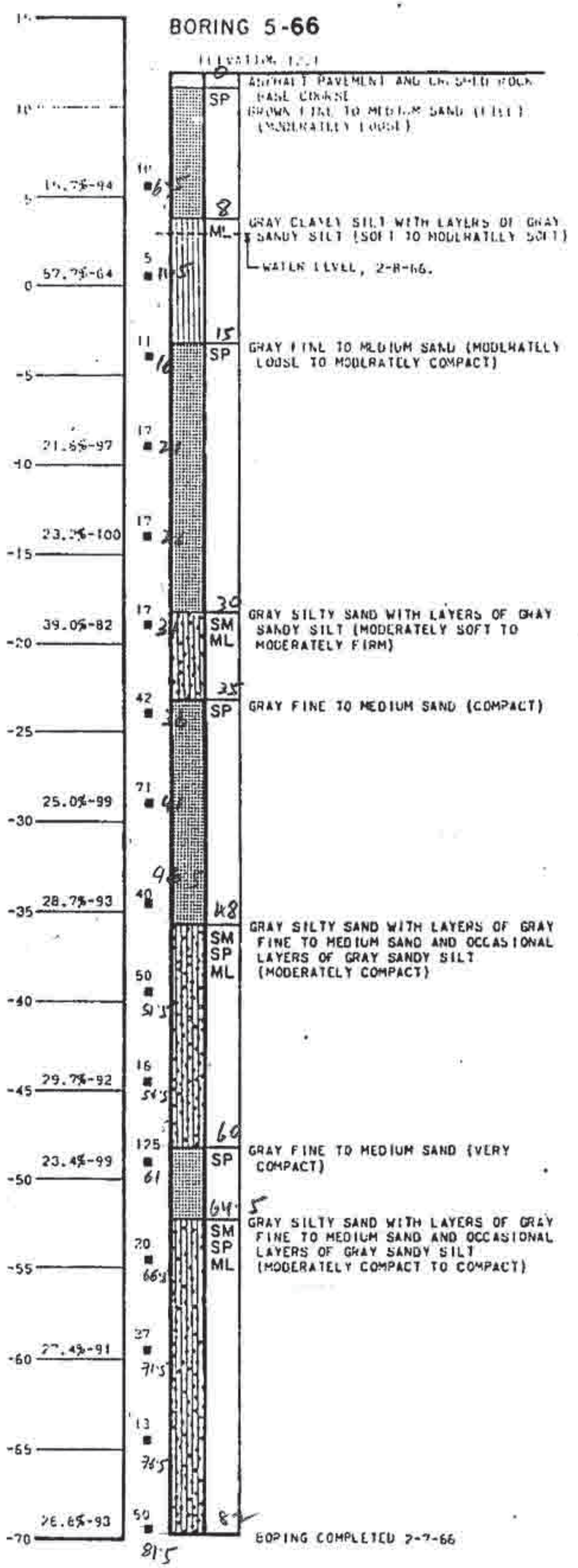
Probe DC-1-89

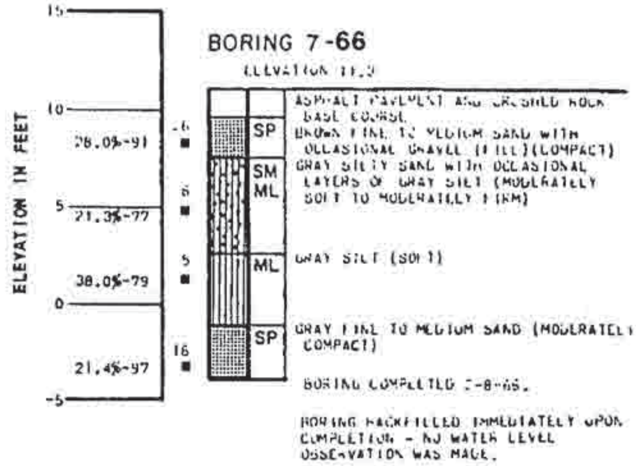


Log of Dutch Cone Probes
Dames & Moore
Plate A-6

Probe DC-1-89, Cont.







Average N = 33.25

Reference: Dames & Moore Report No. 695-102-05, dated March 7, 1966.

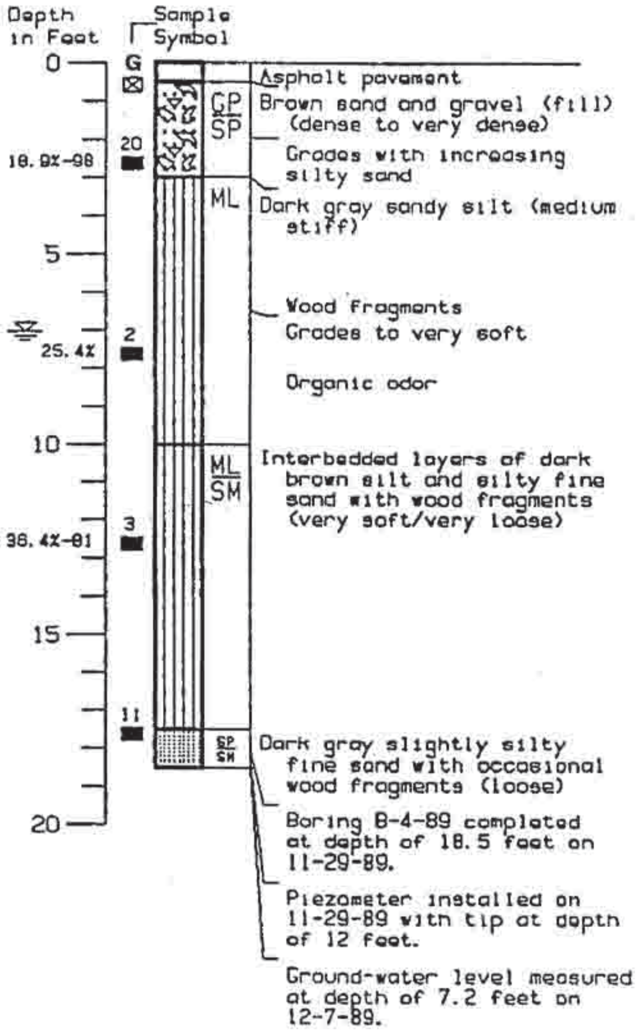
LOG OF BORINGS

Dames & Moore

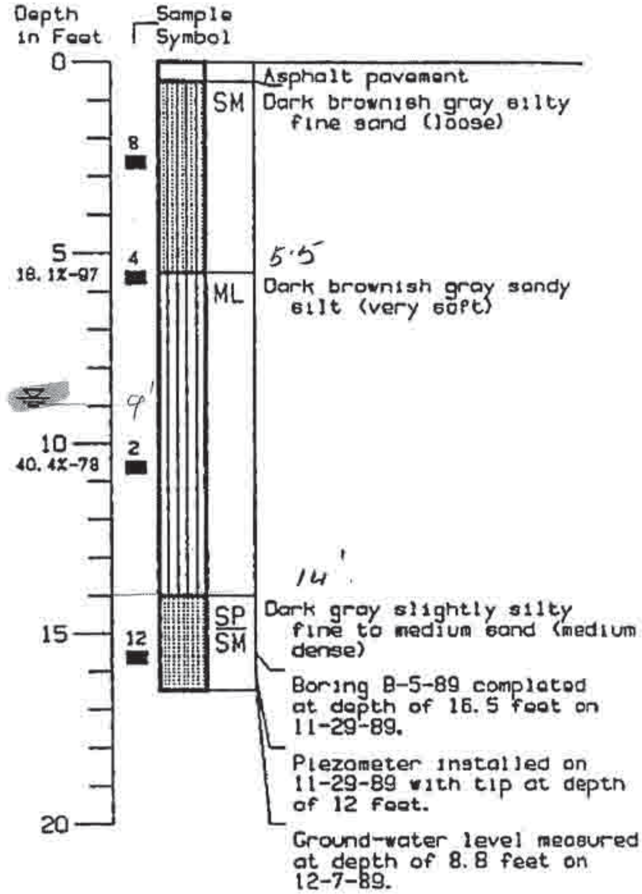
Job No. 685-467-016

Plate 4

Boring B-4-89



Boring B-5-89



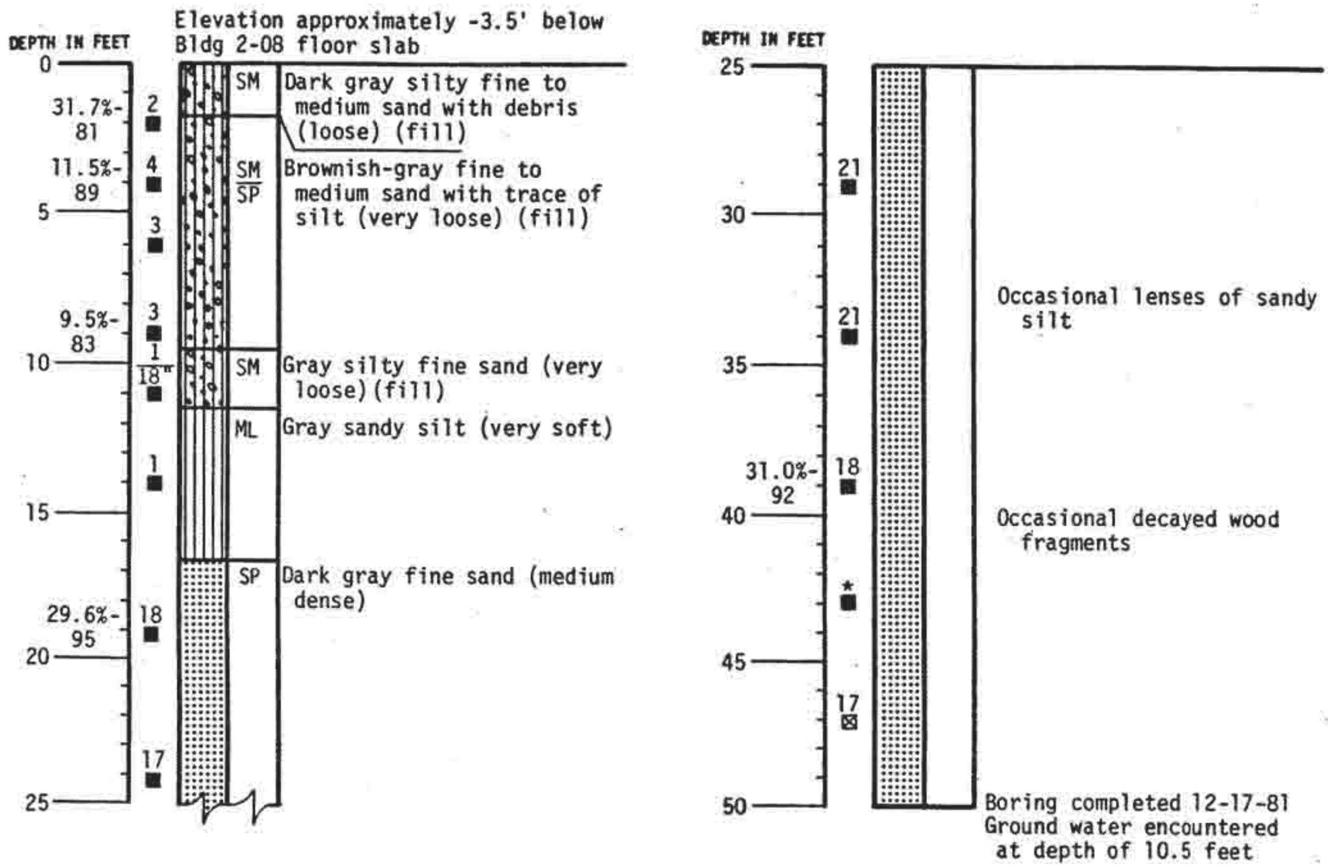
Average N = 6.5
Ignore this because need to get Navy utility upper ...

Log of Borings

Dames & Moore

URS 1982

Boring 1



Key:

MOISTURE CONTENT 31.7%-
81 DRY DENSITY IN PCF

BLOWS REQUIRED TO DRIVE DAMES & MOORE SAMPLER ONE FOOT WITH A HAMMER WEIGHT OF 325 LBS. AND A STROKE OF 30 INCHES.

■ INDICATES DEPTH AT WHICH UNDISTURBED DAMES & MOORE SAMPLE WAS EXTRACTED.

⊠ INDICATES DEPTH AT WHICH DISTURBED DAMES & MOORE SAMPLE WAS EXTRACTED.

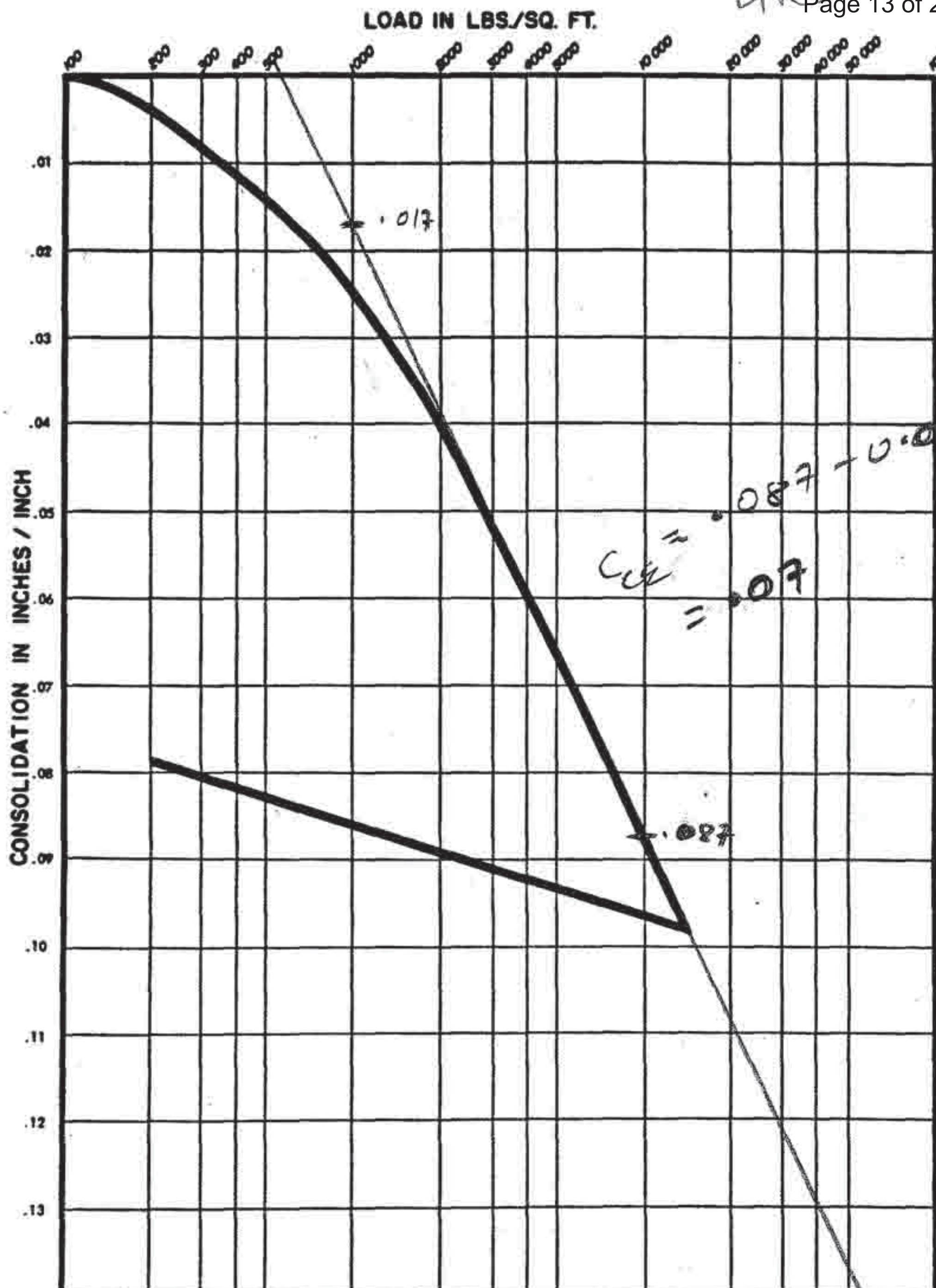
Note:

THE DISCUSSION IN THE TEXT OF THIS REPORT IS NECESSARY FOR A PROPER UNDERSTANDING OF THE NATURE OF THE SUBSURFACE MATERIAL.

* Blow count not representative

LOG OF BORINGS

Dames & Moore



BORING	DEPTH	SOIL TYPE	MOISTURE CONTENT BEFORE	MOISTURE CONTENT AFTER	DRY DENSITY IN LBS./CU. FT.
1	13.8	ML	40.8%	33.3%	87

CONSOLIDATION TEST DATA

Dames & Moore

Job No. 695-264

Plate

URS (1990)

Boring No.	Depth (ft)	Soil Type	Moisture Content (%)	Dry Density (pcf)	Fines Content (%)
B-1-89	15.5	Slightly silty sand	24.9	94	12
B-1-89	50.5	Silty sand	28.5	94	25
B-2-89	17.5	Slightly silty sand	24	97	5
B-3-89	7.5	Sandy silt	25.8	90	58
B-3-89	12.5	Silty sand	31.1	93	19
B-4-89	12.5	Silt	36.4	81	96
B-5-89	5.5	Sandy silt	18.1	97	57

Note: Fines content is defined as the percent by weight of material passing a #200 sieve.

$(\gamma_d)_{ave} = \frac{90+81+97}{3} = 89.3$

$e = \frac{G_s \gamma_w}{\gamma_d} - 1 = \frac{2.65 \times 62.4}{89.3} - 1 = .85$

FINES CONTENT ANALYSIS TEST RESULTS

$\gamma = 97\left(1 + \frac{18.1}{100}\right) = 114.5$ pcf

Silt/Sandy silt $w_n = \frac{25.8 + 36.4 + 18.1}{3} = 26.8\%$

$C_c = .01 w_n = .267$ $C_{\epsilon\epsilon} = \frac{C_c}{1+e} = \frac{.267}{1.85} = .144$

URS

Job: North Boeing Field	Project No. 33762889	Page ____ of ___ Sheet____ of ____
Description: Foundation	Computed by: SB	Date 4/18/11
	Checked by:	Date __________

CALCULATIONS:

(a) **Selection of PGA**

- Based on the 2009 IBC:

  Average N is between 15 to 50, Therefore site class is D, see page 16
  Peak Ground Acceleration, PGA = 0.413 g, see pages 17 and 18

(b) **Selection of Earthquake magnitude (M)**

- Based on the USGS (2002):
  For Boeing site, Mean M=6.6, see page 19

(c) **Evaluation of liquefaction potential**

- Analysis was performed using LiquefyPro software. Fines correction was performed using Stark/Olson et. al. In this analysis, the fines contents were estimated using the description of the soils on the boring logs.
- See pages 20 and 21.

(d) **Estimation of settlement due to earthquake**

- Analysis was performed using LiquefyPro software utilizing Tokimatsu- M correction approach.

(e) **Estimation of $C_{C\epsilon}$**

- Estimated $C_{C\epsilon}$ using laboratory test performed in the vicinity of the project site, see page 13
- Estimated $C_{C\epsilon}$ using published correlations, see pages 14 and 22
- Based on both approach, selected $C_{C\epsilon}$ for long term settlement estimation is 0.14

(f) **Estimation of long term settlement**

- Based on the borings (B-5-89 and B-5-66) in the vicinity of the project area, URS estimated an idealized soil profile at project location as follows:
  - 0 to 5.5 feet: loose silty SAND [SM]
  - 5.5 to 14 feet: soft sandy SILT [ML]
  - Greater than 14 feet: loose to medium dense silty SAND/poorly graded SAND [SM/SP]
- Long term settlements were estimated for the 40-foot wide and 50-foot long, 20-foot wide and 25-foot long, 10-foot wide and 25-foot long, and 20-foot wide and 40-foot long mat foundations.

ELECTRONIC FILE LOCATION:

- Electronic files are saved under the following folder:

  G:\Boeing\North Boeing Field\Geotechnical Work\Calculation

  G is 163 on ‘seaocean’

TABLE 1613.5.2
SITE CLASS DEFINITIONS

SITE CLASS	SOIL PROFILE NAME	AVERAGE PROPERTIES IN TOP 100 feet, SEE SECTION 1613.5.5		
		Soil shear wave velocity, $\bar{v}_s$, (ft/s)	Standard penetration resistance, $\bar{N}$	Soil undrained shear strength, $\bar{s}_u$, (psf)
A	Hard rock	$\bar{v}_s > 5{,}000$	N/A	N/A
B	Rock	$2{,}500 < \bar{v}_s \leq 5{,}000$	N/A	N/A
C	Very dense soil and soft rock	$1{,}200 < \bar{v}_s \leq 2{,}500$	$\bar{N} > 50$	$\bar{s}_u \geq 2{,}000$
D	Stiff soil profile	$600 \leq \bar{v}_s \leq 1{,}200$	$15 \leq \bar{N} \leq 50$	$1{,}000 \leq \bar{s}_u \leq 2{,}000$
E	Soft soil profile	$\bar{v}_s < 600$	$\bar{N} < 15$	$\bar{s}_u < 1{,}000$
E	—	Any profile with more than 10 feet of soil having the following characteristics: 1. Plasticity index $PI > 20$, 2. Moisture content $w \geq 40\%$, and 3. Undrained shear strength $\bar{s}_u < 500$ psf		
F	—	Any profile containing soils having one or more of the following characteristics: 1. Soils vulnerable to potential failure or collapse under seismic loading such as liquefiable soils, quick and highly sensitive clays, collapsible weakly cemented soils. 2. Peats and/or highly organic clays ($H > 10$ feet of peat and/or highly organic clay where H = thickness of soil) 3. Very high plasticity clays ($H > 25$ feet with plasticity index $PI > 75$) 4. Very thick soft/medium stiff clays ($H > 120$ feet)		

For SI: 1 foot = 304.8 mm, 1 square foot = 0.0929 m^2, 1 pound per square foot = 0.0479 kPa. N/A = Not applicable

TABLE 1613.5.3(1)
VALUES OF SITE COEFFICIENT F_a [a]

SITE CLASS	MAPPED SPECTRAL RESPONSE ACCELERATION AT SHORT PERIOD				
	$S_s \leq 0.25$	$S_s = 0.50$	$S_s = 0.75$	$S_s = 1.00$	$S_s \geq 1.25$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	Note b	Note b	Note b	Note b	Note b

a. Use straight-line interpolation for intermediate values of mapped spectral response acceleration at short period, S_s.
b. Values shall be determined in accordance with Section 11.4.7 of ASCE 7.

TABLE 1613.5.3(2)
VALUES OF SITE COEFFICIENT F_V [a]

SITE CLASS	MAPPED SPECTRAL RESPONSE ACCELERATION AT 1-SECOND PERIOD				
	$S_1 \leq 0.1$	$S_1 = 0.2$	$S_1 = 0.3$	$S_1 = 0.4$	$S_1 \geq 0.5$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.7	1.6	1.5	1.4	1.3
D	2.4	2.0	1.8	1.6	1.5
E	3.5	3.2	2.8	2.4	2.4
F	Note b	Note b	Note b	Note b	Note b

a. Use straight-line interpolation for intermediate values of mapped spectral response acceleration at 1-second period, S_1.
b. Values shall be determined in accordance with Section 11.4.7 of ASCE 7.

~~**1803.5.12 Seismic Design Categories D through F.**~~ For structures assigned to *Seismic Design Category* D, E or F in accordance with Section 1613, the geotechnical investigation required by Section 1803.5.11, shall also include:

1. The determination of lateral pressures on foundation ~~walls and retaining walls due to earthquake motions.~~
2. The potential for liquefaction and soil strength loss evaluated for site peak ground accelerations, magnitudes and source characteristics consistent with the design earthquake ground motions. Peak ground acceleration shall be permitted to be determined based on a site-specific study taking into account soil amplification effects, as specified in Chapter 21 of ASCE 7, or, in the absence of such a study, peak ground accelerations shall be assumed equal to $S_{DS}/2.5$, where S_{DS} is determined in accordance with Section 1613.5.4.
3. An assessment of potential consequences of liquefaction and soil strength loss, including estimation of differential settlement, lateral movement, lateral loads on foundations, reduction in foundation soil-bearing capacity, increases in lateral pressures on retaining walls and flotation of buried structures.
4. Discussion of mitigation measures such as, but not limited to, ground stabilization, selection of appropriate foundation type and depths, selection of appropriate structural systems to accommodate anticipated displacements and forces, or any combination of these measures and how they shall be considered in the design of the structure.

1803.6 Reporting. Where geotechnical investigations are required, a written report of the investigations shall be submitted to the *building official* by the owner or authorized agent at the time of *permit* application. This geotechnical report shall include, but need not be limited to, the following information:

1. A plot showing the location of the soil investigations.
2. A complete record of the soil boring and penetration test logs and soil samples.
3. A record of the soil profile.
4. Elevation of the water table, if encountered.
5. Recommendations for foundation type and design criteria, including but not limited to: bearing capacity of natural or compacted soil; provisions to mitigate the effects of expansive soils; mitigation of the effects of liquefaction, differential settlement and varying soil strength; and the effects of adjacent loads.
6. Expected total and differential settlement.
7. Deep foundation information in accordance with Section 1803.5.5.
8. Special design and construction provisions for foundations of structures founded on expansive soils, as necessary.
9. Compacted fill material properties and testing in accordance with Section 1803.5.8.
10. ~~Controlled low-strength material properties and testing~~ in accordance with Section 1803.5.9.

SECTION 1804
EXCAVATION, GRADING AND FILL

1804.1 Excavation near foundations. Excavation for any purpose shall not remove lateral support from any foundation without first underpinning or protecting the foundation against settlement or lateral translation.

1804.2 Placement of backfill. The excavation outside the foundation shall be backfilled with soil that is free of organic material, construction debris, cobbles and boulders or with a controlled low-strength material (CLSM). The backfill shall be placed in lifts and compacted in a manner that does not damage the foundation or the waterproofing or dampproofing material.

Exception: CLSM need not be compacted.

1804.3 Site grading. The ground immediately adjacent to the foundation shall be sloped away from the building at a slope of not less than one unit vertical in 20 units horizontal (5-percent slope) for a minimum distance of 10 feet (3048 mm) measured perpendicular to the face of the wall. If physical obstructions or lot lines prohibit 10 feet (3048 mm) of horizontal distance, a 5-percent slope shall be provided to an *approved* alternative method of diverting water away from the foundation. Swales used for this purpose shall be sloped a minimum of 2 percent where located within 10 feet (3048 mm) of the building foundation. Impervious surfaces within 10 feet (3048 mm) of the building foundation shall be sloped a minimum of 2 percent away from the building.

Exception: Where climatic or soil conditions warrant, the slope of the ground away from the building foundation shall be permitted to be reduced to not less than one unit vertical in 48 units horizontal (2-percent slope).

The procedure used to establish the final ground level adjacent to the foundation shall account for additional settlement of the backfill.

1804.4 Grading and fill in flood hazard areas. In *flood hazard areas* established in Section 1612.3, grading and/or fill shall not be *approved*:

1. Unless such fill is placed, compacted and sloped to minimize shifting, slumping and erosion during the rise and fall of flood water and, as applicable, wave action.
2. In floodways, unless it has been demonstrated through hydrologic and hydraulic analyses performed by a *registered design professional* in accordance with standard engineering practice that the proposed grading or fill, or both, will not result in any increase in flood levels during the occurrence of the *design flood*.
3. In flood hazard areas subject to high-velocity wave action, unless such fill is conducted and/or placed to avoid diversion of water and waves toward any building or structure.
4. Where design flood elevations are specified but floodways have not been designated, unless it has been demonstrated that the cumulative effect of the proposed

Conterminous 48 States
2009 International Building Code
Latitude = 47.538095
Longitude = -122.318215
Spectral Response Accelerations Ss and S1
Ss and S1 = Mapped Spectral Acceleration Values
Site Class B - Fa = 1.0 ,Fv = 1.0
Data are based on a 0.05 deg grid spacing

Period (sec)	Sa (g)
0.2	1.550 (Ss, Site Class B)
1.0	0.534 (S1, Site Class B)

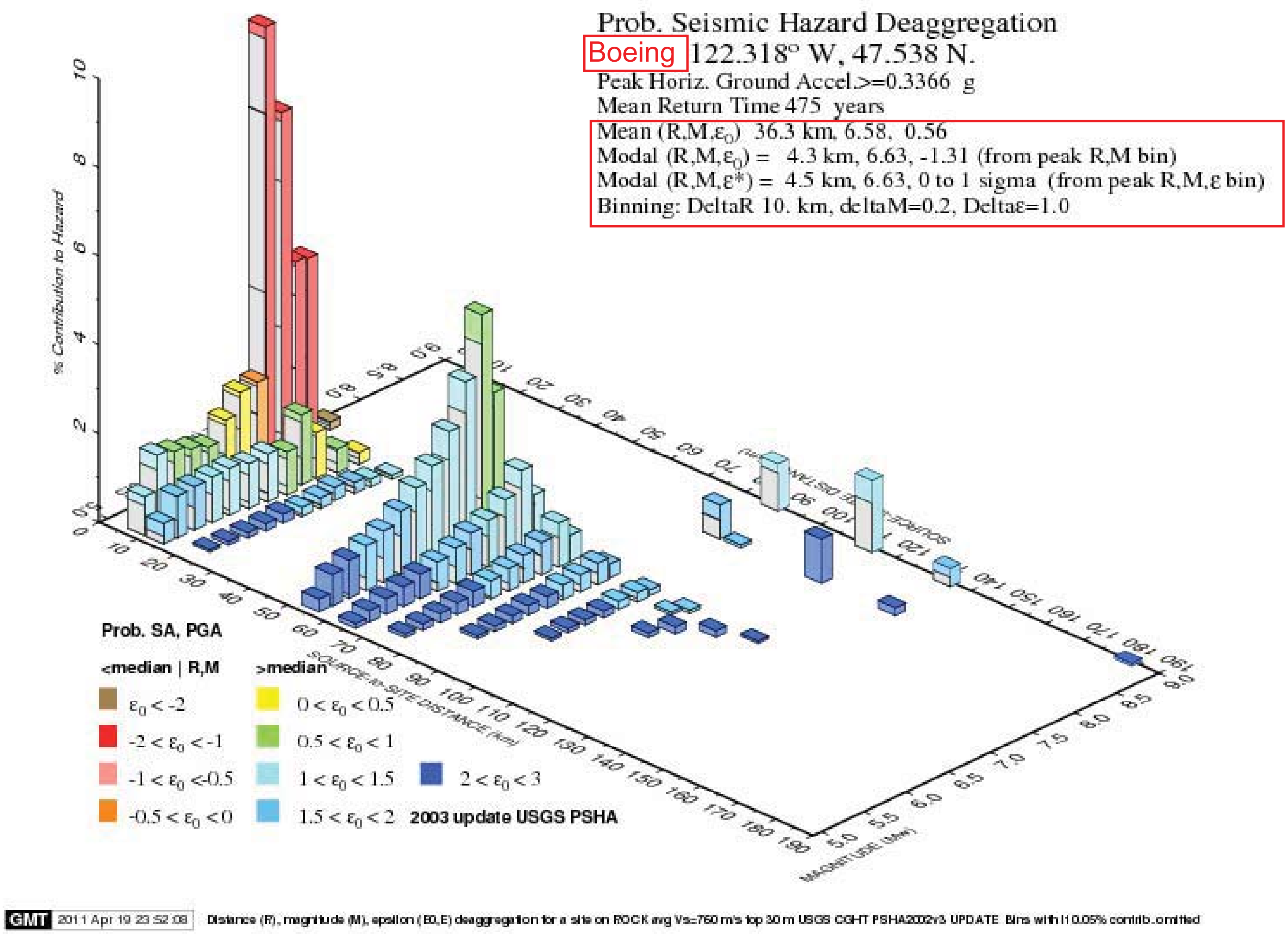
Conterminous 48 States
2009 International Building Code
Latitude = 47.538095
Longitude = -122.318215
Spectral Response Accelerations SMs and SM1
SMs = Fa x Ss and SM1 = Fv x S1
Site Class D - Fa = 1.0 ,Fv = 1.5

Period (sec)	Sa (g)
0.2	1.550 (SMs, Site Class D)
1.0	0.802 (SM1, Site Class D)

PGA=SDs/2.5=1.033/2.5=.413 g

Conterminous 48 States
2009 International Building Code
Latitude = 47.538095
Longitude = -122.318215
Design Spectral Response Accelerations SDs and SD1
SDs = 2/3 x SMs and SD1 = 2/3 x SM1
Site Class D - Fa = 1.0 ,Fv = 1.5

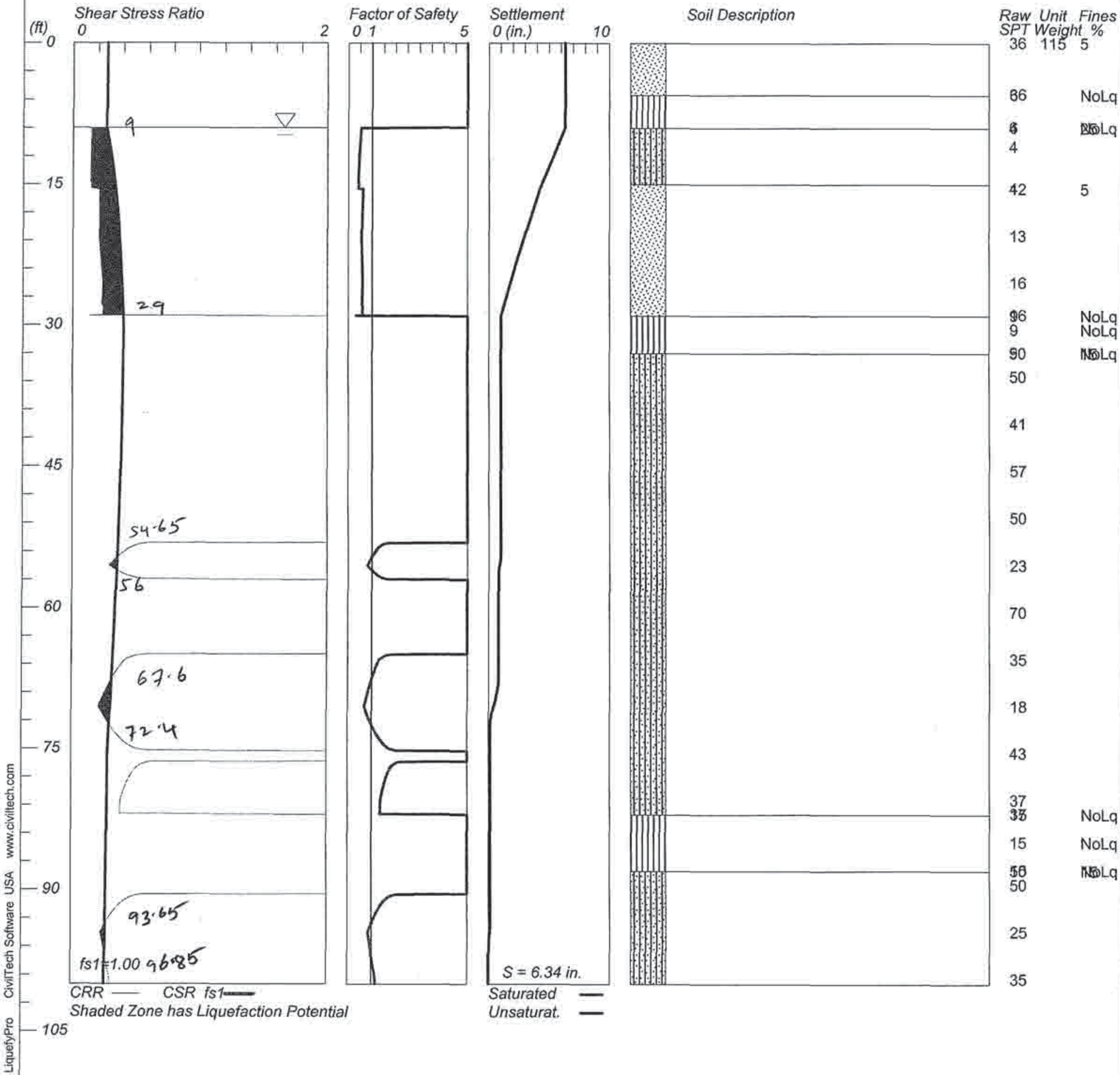
Period (sec)	Sa (g)
0.2	1.033 (SDs, Site Class D)
1.0	0.534 (SD1, Site Class D)


Prob. Seismic Hazard Deaggregation
Boeing 122.318° W, 47.538 N.
Peak Horiz. Ground Accel.>=0.3366 g
Mean Return Time 475 years
Mean (R,M,ε_0) 36.3 km, 6.58, 0.56
Modal (R,M,ε_0) = 4.3 km, 6.63, -1.31 (from peak R,M bin)
Modal (R,M,ε*) = 4.5 km, 6.63, 0 to 1 sigma (from peak R,M,ε bin)
Binning: DeltaR 10. km, deltaM=0.2, Deltaε=1.0
% Contribution to Hazard
SOURCE-to-SITE DISTANCE (km)
MAGNITUDE (Mw)
Prob. SA, PGA
<median | R,M
>median
ε_0 < -2
-2 < ε_0 < -1
-1 < ε_0 <-0.5
-0.5 < ε_0 < 0
0 < ε_0 < 0.5
0.5 < ε_0 < 1
1 < ε_0 < 1.5
1.5 < ε_0 < 2
2 < ε_0 < 3
2003 update USGS PSHA
GMT 2011 Apr 19 23:52:08
Distance (R), magnitude (M), epsilon (E0,E) deaggregation for a site on ROCK avg Vs=760 m/s top 30 m USGS CGHT PSHA2002v3 UPDATE Bins with lt 0.05% contrib. omitted

Boeing

Hole No.=B-2-66 Water Depth=9 ft

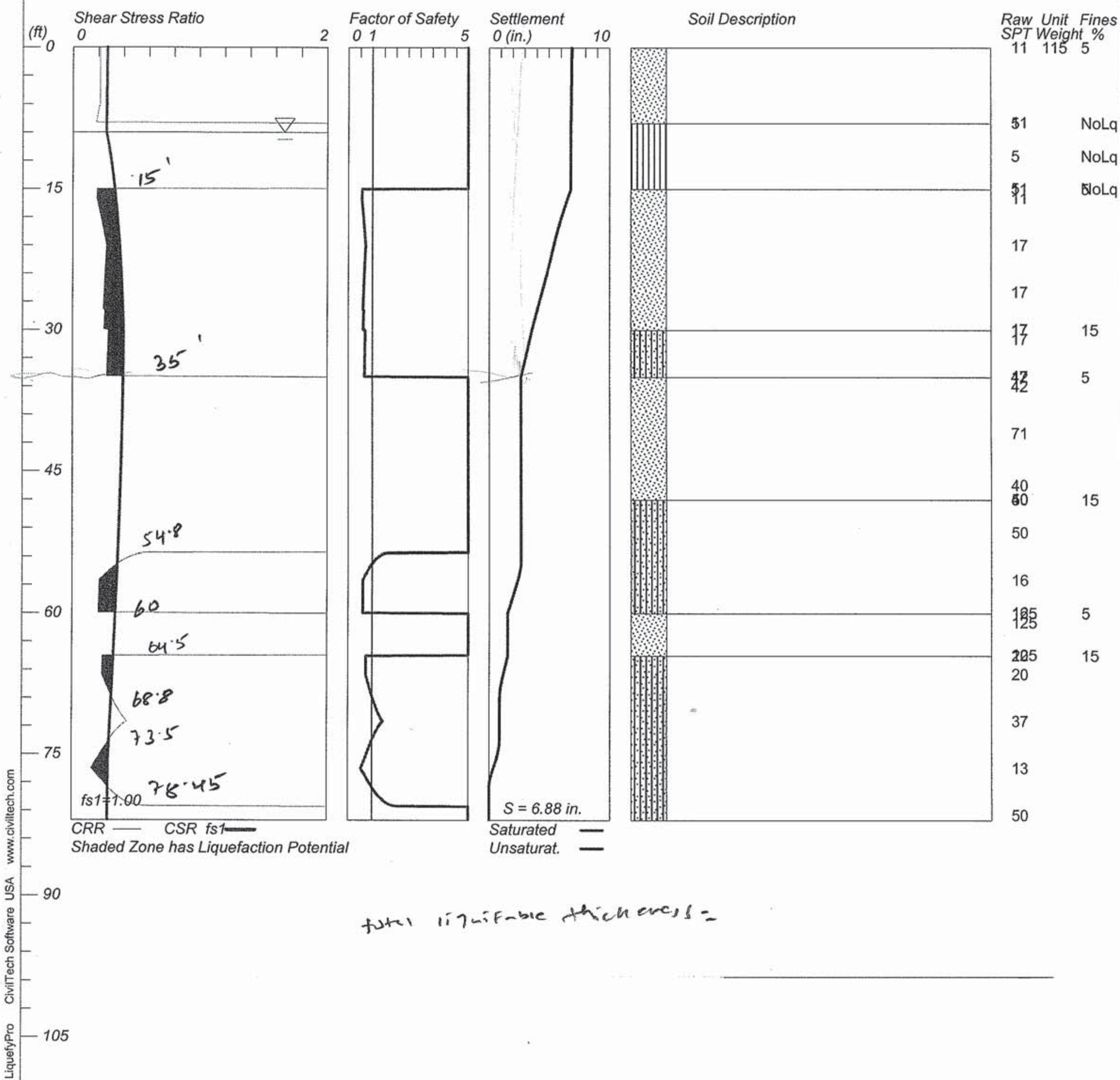
Magnitude=6.6
Acceleration=0.413g



Boeing

Hole No.=B-5-66 Water Depth=9 ft

Magnitude=6.6
Acceleration=0.413g



total liquifable thickness =

Gs= 2.65

Boring No	Depth(Ft)	Soil Type	Moisture Content (%)	Dry Density (pcf)	e	C_C	$C_{C\epsilon}$
B-3-89	7.5	Sandy Silt	25.8	90	0.84	0.258	0.140
B-4-89	12.5	Silt	36.4	81	1.04	0.364	0.178
B-5-89	5.5	Sandy Silt	18.1	97	0.70	0.181	0.106
						Average	**0.142**

$e=G_s*Y_w/Y_d-1$

$C_C=0.01*W_n$

$C_{C\epsilon}=C_C/(1+e)$

URS

Job: North Boeing Field	Project No. 33762889	Page ____ of ___ Sheet____ of ____
Description: Foundation	Computed by: SB	Date 4/18/11
	Checked by:	Date __________

RESULTS and CONCLUSION:

- Liquefaction induced settlement

	Borehole	
	B-2-66	B-5-66
Total thickness of liquefaction zone (ft)	34.45	29.35
Depth of liquefied zone (ft)	9-29, 54.65-56, 67.6-72.4, 93.65-96.85	15-35, 54.8-60, 64.5-68.8, 73.5-78.45
Settlement (inch)	6.34	6.88

- Allowable pressure for mat foundation design = 500 psf
- Long term settlement

Footing Dimension	Settlement (inch)	
	Center	Edge
40-foot wide and 50-foot long	2.84	1.63
20-foot wide and 25-foot long	2.37	1.43
10-foot wide and 25-foot long	1.86	1.29
20-foot wide and 40-foot long	2.49	1.52

SECTION 16111

RACEWAY

1. GENERAL

1.1 DESCRIPTION OF WORK

A. This section includes conduit, electrical metallic tubing, wireway, and surface metal raceway.

1.2 REFERENCES

A.	UL 1	Flexible Metal Electrical Conduit
B.	UL 6	Rigid Metal Electrical Conduit
C.	UL 360	Liquid-Tight Flexible Steel Conduit, Electrical
D.	UL 514B	Fittings for Conduit and Outlet Boxes
E.	UL 651	Schedule 40 and 80 Rigid PVC Conduit (PVC)
F.	UL 651A	Type EB and A PVC Conduit and HDPE Conduit
G.	UL 797	Electrical Metallic Tubing (EMT)

2. PRODUCTS

2.1 RIGID METAL CONDUIT AND FITTINGS

A. Ferrous metal conduit:
   1. UL 6, hot-dip galvanized.
   2. Fittings and conduit bodies: UL 514B, galvanized.

B. PVC-coated ferrous metal conduit :
   1. UL 6, hot-dip galvanized with 40-mil PLC coating, inside and out.
   2. Fittings and conduit bodies: UL 514B, galvanized with 40-mil PVC coating.

2.2 ELECTRICAL METALLIC TUBING (EMT) AND FITTINGS

A. Ferrous metal: UL 797, galvanized.

B. Fittings: UL 514B, galvanized steel, compression ring type. Set screw and drive-on type are not acceptable.

2.3 LIQUID-TIGHT FLEXIBLE METAL CONDUIT AND FITTINGS

A. Ferrous metal galvanized with PVC weatherproof cover: UL 360.

B. Fittings: UL 514B, galvanized steel, UL listed for grounding as available.

2.4 RIGID NONMETALLIC CONDUIT (PVC)

A. UL 651, schedule 40, rigid PVC type, unless noted otherwise. UL 651A type EB permitted for underground rebar reinforced concrete duct banks. PVC elbows not permitted.

3. EXECUTION

3.1 RACEWAY SCHEDULE

A. Rigid steel conduit
   1. All exposed exterior locations.
   2. Within eight feet of floor in exposed interior locations.
   3. 3/4-inch trade size minimum below grade.
   4. Panel, MCC, transformer, and busway feeders.

B. EMT
   1. Dry, protected indoor locations only.
   2. Steel connectors or couplings only.
   3. Not acceptable for feeders.

C. Liquidtight flexible steel conduit:
   1. Locations exposed to vibration (motors, transformers).
   2. Complex contours.

D. PVC
   1. Not allowed, except where encased in concrete. See Section 3.3.

E. PVC-coated rigid steel conduit:
   1. All locations below grade.

3.2 SIZING, ARRANGEMENT, AND SUPPORT

A. Unless otherwise shown, size conduit for conductor type installed. Minimum size 3/4 inch.

B. Install raceway to maintain headroom and present a neat appearance in unfinished spaces.

C. Install EMT and conduit concealed in finished spaces.

D. Route raceway parallel and perpendicular to building planes.

E. Maintain minimum 6-inch clearance between raceway and piping. Maintain 12-inch clearance between raceway and heat sources such as flues, steam pipes, and heating appliances.

F. Brace EMT and conduit, and supports, to prevent distortion of alignment by wire-pulling operations.

G. Where EMT and conduit are run in parallel, group on formed channel supports with space for 25% additional conduit (minimum one conduit of the largest size in the run or one, 1-inch conduit, whichever is larger).

H. Do not fasten raceways with wire or perforated pipe straps. Remove temporary conduit support used during construction before conductors are pulled.

3.3 CONDUIT INSTALLATION

A. Cut conduit square using a saw or pipecutter; deburr cut ends.

B. Bring conduit to the shoulder of fittings and couplings and tighten securely.

C. Use threaded conduit hubs for fastening conduit to cast boxes, and for fastening conduit to sheet metal boxes in damp or wet locations.

D. Do not use conduit bodies to make sharp changes in direction, unless approved.

E. Use hydraulic one-shot conduit bender or factory elbows for bends in 2 inch conduit and larger.

F. Provide insulated bushings at every conduit termination, for conduits larger than 1 inch. Grounding type where shown on the Drawings, or as required by NEC.

G. Use suitable conduit caps to protect installed conduit against entrance of dirt and moisture.

H. Provide No. 10 steel wire or 1/4-inch poly rope pull string in empty conduit, except sleeves and nipples.

I. Raceways Underground:
   1. Rigid galvanized steel painted with two coats of bitumastic paint; or rigid galvanized steel with a 40 mil. PVC jacket (repair abrasions with PVC base paint).
   2. Rigid nonmetallic conduit may be used, where completely encased with a minimum of 2 inches of concrete. Form field bends only with manufacturer's recommended heater. Penetrations through floor: PVC-coated rigid steel. Stub ups: PVC-coated rigid steel elbows. Increase raceway size as necessary to comply with code required ground wire. For bends in PVC runs of less than 10-foot radius, use Schedule 40 rigid galvanized steel.

3. Arrange and slope raceways entering building to drain away from building.
4. Provide marker tape over underground raceways.
5. Install underground raceways 24-inches minimum below final grade, unless otherwise noted on the Drawings.
6. Backfill underground raceways with material the size of pea gravel or smaller to 3 inches above and below raceways. Backfill to 12 inches above raceways is required to be free of debris or rocks greater than 1 inch in diameter.
7. Raceways under slab on grade: 4 inches, minimum, below floor.
8. Install raceways that stub up through floor at such depth that the exposed raceway is vertical and no curved section of the elbow is visible. Provide coupling flush with floor.

J. Sealing of Raceways:
1. Seal interior of raceways that pass through outside walls of the building, above or below grade. Seal on the end inside the building. Use raceway sealing fittings manufactured for the purpose sealed with non-hardening, compound-type mastic, specially designed for such service. Pack around the wires in the raceways.
2. For exterior wall penetrations below grade, install sealing bushing at interior end of penetrating raceway. Threaded fittings - only - are permitted in entering raceways ahead of the sealing bushing.

* * * END OF SECTION * * *

SECTION 16120

WIRE AND CABLE

1. GENERAL

1.1 DESCRIPTION OF WORK

A. This section includes:
   1. Building wire, 600V and less.
   2. Cable, 600V and less.
   3. Wiring connections and terminations, 600V and less.

1.2 REFERENCES

A. NEMA WC 3 Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.

B. NEMA WC 5 Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.

C. NEMA WC 7 Cross-Linked-Thermosetting-Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.

1.3 SUBMITTALS

A. Submit Shop Drawings and product data under the provisions of Section 01300, Submittal Procedures.

2. PRODUCTS

2.1 BUILDING WIRE

A. Thermoplastic-insulated building wire. NEMA WC 5.

B. Rubber-insulated building wire: NEMA WC 3.

C. Feeders and branch circuits: Copper conductor, stranded, 600 volt insulation, THHN, THWN.

D. Control circuits: Copper, stranded conductor, 600-volt insulation, THHN, THWN, MTW.

2.2 REMOTE CONTROL AND SIGNAL CABLE

A. Control cable for Class 1 remote control and signal circuits: Copper conductor, 600-volt insulation, rated 60°C, individual conductors twisted together and covered with an overall PVC jacket.

B. Control cable for Class 2 or Class 3 remote control and signal circuits: Copper conductor, 300-volt insulation, rated 60 °C, individual conductors twisted together and covered with a PVC jacket, UL listed.

C. Plenum cable for Class 2 or Class 3 remote control and signal circuits: Copper conductor, 300-volt insulation, rated 60°C, individual conductors twisted together and covered with a non-metallic jacket; UL listed for use in air-handling ducts, hollow spaces used as ducts, and plenums.

3. EXECUTION

3.1 GENERAL WIRING METHODS

A. Use wire no smaller than 12 AWG for power and lighting circuits.

B. Use 10 AWG conductor for 20-ampere, 120-volt branch circuit home runs longer than 75 feet, and for 20-ampere, 277-volt branch circuit home runs longer than 200 feet.

C. Place an equal number of conductors for each phase of a circuit in same raceway or cable.

D. Feeders shall not be spliced. Splice branch circuits only in junction or outlet boxes.

E. Neatly train and lace wiring inside boxes, equipment, and panel boards.

F. Use equal conductor lengths for parallel circuits.

3.2 WIRING INSTALLATION IN RACEWAY

A. Pull all conductors into a raceway at the same time. Use UL-listed wire-pulling lubricant for pulling 4 AWG and larger wires.

B. Install wire in raceway after interior of building has been protected from the weather and mechanical work likely to injure conductors has been completed.

C. Completely and thoroughly swab raceway system before installing conductors.

3.3 CABLE INSTALLATION

A. Provide protection for exposed cables where subject to damage.

B. Support cables above accessible ceilings; do not rest on ceiling tiles. Use spring metal slips or plastic cable ties to support cables from structure or ceiling suspension system. Include bridle rings or drive rings.

C. Use suitable cable fittings and connectors.

3.4 WIRING CONNECTIONS AND TERMINATIONS

A. Splice power wiring only in accessible junction boxes. Control wiring shall not be spliced.

B. Use solderless pressure connectors with insulating covers for copper wire splices and taps, 8 AWG and smaller. For 10 AWG and smaller, use insulated spring wire connectors with plastic caps.

C. Use split bolt connectors for copper wire splices and taps, 6 AWG and larger. Tape uninsulated conductors and connectors with electrical tape to 150% of the insulation value of conductor.

D. Thoroughly clean wires before installing lugs and connectors.

E. Make splices, taps and terminations to carry full capacity of conductors without perceptible temperature rise. Feeders shall not be spliced.

F. Terminate spare conductors with electrical tape.

3.5 FIELD QUALITY CONTROL

A. Field inspection and testing will be performed under provisions of Section 01450, Quality Control.

B. Inspect wire and cable for physical damage and proper connection.

C. Torque test conductor connections and terminations to manufacturer's recommended values.

D. Perform continuity test on all power and equipment branch circuit conductors. Verify proper phasing connections.

3.6 WIRE AND CABLE INSTALLATION SCHEDULE

A. Use building wire in raceways for concealed and exposed interior locations, above accessible ceilings, in wet or damp interior locations, in exterior locations, and underground.

* * * END OF SECTION * * *

SECTION 16125

MEDIUM-VOLTAGE CABLE

1. GENERAL

1.1 DESCRIPTION OF WORK

A. This section includes 5 kV Shielded Power Cable, Single Conductor, Type MV-90.

1.2 REFERENCES

A. The latest edition of the following publications form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

1. ICEA S-68-516 Ethylene-Propylene-Rubber-Insulated Wire and Cable.
2. AEIC CS6 Specifications for Ethylene Propylene Rubber Insulated Shielded Power Cables Rated 5 through 35KV.
3. ANSI/IEEE C2 National Electrical Safety Code.
4. ASTM B8 Standard Specification for Concentric-Lay-Stranded Copper Conductors.
5. UL-1072 Medium-Voltage Power Cables
6. D180-14302-3 Medium-Voltage Cable Testing (Boeing Facility Standard).
7. Vol III, Sec 11.
8. NFPA 70 National Electrical Code, (Article 326) Medium Voltage Cable, Type MV.

1.3 CABLE DESCRIPTION

A. UL listed, Type MV-90, single conductor, shielded power cable insulated with an ozone and discharge resistant dielectric.

B. Suitable for use in wet or dry locations; indoor or outdoor, including direct sunlight.

C. Suitable for routing in conduit, underground duct systems, or cable tray.

D. Rated 90°C for normal operation, 130°C for emergency overload operation, and 250°C for short circuit conditions. Emergency overload operation may occur for periods up to 1500 hours cumulative during the life of the cable.

E. Size: 500 kcmil.

1.4 SUBMITTALS

A. Procedure: Conform to Specification Section 01300 - Submittal Procedures.

B. At time of bid response, provide necessary descriptive literature and factory data sheets to verify that each proposed cable meets or exceeds these specifications.

C. Provide written certification that cable manufacturer has a performance record demonstrating a minimum of twenty years successful operating experience in utility and industrial power cable applications.

D. Provide cable pull-tension calculations for each cable installation. Provide written certification of the cable manufacturer's concurrence with the installation calculations and techniques.

E. Provide three copies of all certified test reports required by these specifications.

F. Provide the following information:
   1. Cable dimensions and weight.
   2. Cable ampacity (including basis/conditions for rating).
   3. Cable splicing and termination recommendations.
   4. Recommended DC voltage for field testing of cable

1.5 WARRANTY

A. Provide a two year warranty. This warranty shall begin upon delivery at the project site and acceptance by The Boeing Company (see Section 3.2).

1.6 QUALITY ASSURANCE

A. Provide manufacturer's documentation that each cable is manufactured and tested under a Quality Assurance program that supports continuous quality improvement procedures which meet the intent of Section 10CFR50, Appendix B, of the Federal Register as defined in ANSI N45.2.

B. Demonstrate that the Quality Assurance program is in compliance with the above referenced criteria by written evidence of successfully passing yearly Quality Audits conducted by outside independent organizations.

C. Provide cable of recent manufacture, no more than 12-months old, and in continuous lengths with no splices. Seal ends of cable to prevent moisture penetration into the conductor strands.

1.7 SHIPPING REQUIREMENTS

A. Provide waterproofed shipping tags securely fastened to each cable reel.

B. Clearly mark each cable reel with the following information:

1. Name of manufacturer.
2. Purchase Order number.
3. Reel number and footage (continuous cable length shipped).
4. Product description (type, voltage rating, conductor size, number of conductors).
5. Gross, tare, and net weights.
6. Date of manufacture.

2. PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. The Okonite Company.

B. Rome Cable Corporation.

C. Southwire Company.

D. Substitutions: Any substitution and/or deviation from these specifications must be approved by the Engineer prior to fabrication and delivery.

2.2 BASIC CONSTRUCTION

A. Concentric-lay, stranded, bare copper conductor (see paragraph 2.3).

B. Triple extruded
   1. Semiconducting thermosetting compound strand shield (see paragraph 2.4).
   2. Ethylene-propylene rubber insulation (see paragraph 2.5).
   3. Extruded semiconducting thermosetting compound insulation shield (see paragraph 2.6).

C. Copper shield (see paragraph 2.7).

D. Overall jacket (see paragraph 2.8).

E. Comply with the physical and electrical properties of the insulation and jacket as set forth in the ICEA values scheduled in appendices A, B, and/or C as applicable.

F. Comply with the requirements of NEC Article 326.

2.3 CONDUCTOR

A. Uncoated soft copper wire, concentric-lay, compressed, stranded, Class B, per ASTM B8.

B. Comply with the electrical resistance requirements of ICEA S-68-516, Section 2.5.

2.4 CONDUCTOR SHIELD

A. Extruded layer of semi-conducting thermosetting compound compatible with the overlaying insulation and meeting resistivity requirements of AEIC-CS6, paragraph C.5.

B. The shield shall be clean-stripping from the conductor and inseparably bonded to the overlaying insulation.

C. The minimum thickness of the extruded conductor shield shall be as shown in Table 1. Measure and control the thickness of the shield to meet or exceed all physical and electrical tests prescribed by AEIC specifications.

Table 1: Conductor Shield Thickness

Conductor Size AWG/kcmil	Minimum Point (mils)	Minimum Average (mils)
8 - 4/0	12	15
250 - 500	16	20
600 - 1000	20	25

2.5 INSULATION

A. Provide insulation of a flexible thermosetting dielectric based on an ethylene propylene elastomer. It shall meet the electrical and physical characteristics shown in Appendix . Compounds used in the manufacture of the cable shall be fed from a positive pressure clean room and be conveyed to the extruders through a closed system free from the factory environment.

B. Provide 133 percent insulation. Minimum average insulation thickness not less than as scheduled in Table 2. The minimum thickness at any cross-section of the insulation shall be not less than 90 percent of the specified minimum average thickness.

C. Triple-extrude the insulation with the conductor and insulation shield to prevent intersurface contamination. Perform the extrusion operation by using a triple-extrusion process that permits the measurement and accurate control of the wall thickness of each layer of compound.

Table 2: Insulation Thickness and Withstand Voltages

Rated Voltage Phase to Phase (kV)	Conductor Size	Minimum Average Insulation Thickness (mils)		5 minute ac Withstand (kV)		15 minute dc Withstand (kV)	
		100%	133 %	100 %	133 %	100 %	133 %
5	#8 AWG to 1000 kcmil	--	115	--	23	--	45
8	#6 AWG to 1000 kcmil	115	140	23	28	45	55
15	#2 AWG to 1000 kcmil	175	220	35	44	70	80

2.6 INSULATION SHIELD

A. Apply an extruded semi-conducting thermosetting insulation shield over the insulation.

1. Extruded semiconducting thermosetting compound compatible with the underlaying insulation. Comply with the resistivity requirements of AEIC CS6, Paragraph D.5.
2. Clean stripping. Peel strength from the insulation of between 6 and 24 pounds for a 1/2-inch width when tested per AEIC CS-6. 100 percent minimum elongation after an air oven test at 121°C for 168 hours, and a brittleness temperature not warmer than minus 50°C. The extruded shield shall be in intimate contact with the outer surface of the insulation and shall be free-stripping, leaving no conducting particles or other residue on the insulation surface.
3. Identify the insulation shield by continuously printing, with contrasting colored ink on the outer surface, "Semi-conducting - Remove When Splicing or Terminating."
4. The average thickness of the extruded shield shall be in accordance with AEIC-CS6, Table C3. The minimum and maximum point thickness of the extruded shield shall be in accordance with the values shown in Table 3.

Table 3: Insulation Shield Thickness

Calculated Minimum Diameter (d) Over Insulation	Insulation shield thickness (mils)	
(inches)	Min point	Max point
$d \leq 1.0$	30	70
$1.0 < d \leq 1.5$	40	85
$1.5 < d \leq 2.0$	55	100
$d > 2.0$	55	115

2.7 METALLIC SHIELD

A. Apply a helical 5 mil uncoated annealed copper shielding tape, directly over the extruded insulation shield, with a minimum 12-1/2 percent overlap. Comply with the requirements of Part 4 of ICEA S-68-516.

Table 4: Shield Wire Sizing

5KV Cable		15KV Cable	
Cable Size	Shield Size	Cable Size	Shield Size
#2 - #1/0 AWG	6 #20 AWG	#2 AWG	6 #19 AWG
#2/0 - #4/0 AWG	6 # 19 AWG	#1/0 - #4/0 AWG	6 #18 AWG
250 - 350 kcmil	6 # 18 AWG	250 - 500 kcmil	6 #17 AWG
500 - 750 kcmil	6 #17 AWG	750 kcmil	6 #16 AWG
1000 kcmil	6 #16 AWG	1000 kcmil	6 #15 AWG

2.8 JACKET

A. Overall jacket: Black polyvinylchloride (PVC). Comply with the requirements shown in Appendix B.

B. PVC jacket thickness as scheduled in Table 5. The minimum thickness at any point shall not be less than 80 percent of the specified minimum average thickness.

Table 5: PVC Jacket Thickness

Cable Core Diameter (inches)	Minimum Average Jacket Thickness (mils)
0 - 0.425	45
0.426 - 0.700	60
0.701 - 1.500	80
1.501 - 2.500	110
2.501 & larger	140

2.9 IDENTIFICATION

A. Print the following identifying legend, items 1 thru 11, on the jacket with contrasting ink. Repeat at maximum two foot intervals (unmarked surfaces not exceeding six inches).

1. Cable Manufacturer.
2. Plant Number or letter.
3. Conductor Size (AWG) (KCMIL).
4. C U.
5. Insulation Type (EPR).
6. SHIELDED.
7. Voltage (kV).
8. 133 percent INSULATION LEVEL.
9. Insulation Thickness (MILS).
10. UL.
11. MV-90.

2.10 PRODUCTION TESTS

A. Provide a factory Certified Test Report (CTR) verifying results of the following test requirements for each cable:

1. Conductors shall meet the electrical resistance requirements of ICEA-68-516 Section 2.5.
2. Perform insulation resistance tests in accordance with the requirements of ICEA S-68-516, Part 6.8. Each cable shall have an insulation resistance not less than that corresponding to the insulation resistance constant of at least 50,000 megohm-1000ft. at 15.6°C.
3. Perform high voltage ac and dc tests in accordance with Part 6.27 of ICEA S-68-516 at the ac and dc test voltages given in Table 2. Do not exceed the indicated ac test voltages.
4. Measure and record the shield resistance from end to end on the completed cable.
5. Partial discharge: Comply with the maximum partial discharge in picocoulombs specified in Table 6. Perform the partial discharge test in accordance with the procedures of Section F of AEIC CS-6. Furnish an X-Y recording graph showing the partial discharge (corona) test results.

Table 6: Partial Discharge Test Requirements

Vt/ Vg ratio:	1.0	1.5	2.5	3.0	4.0
AEIC CS-6 Reqmts (pc):	5	5	5	5	10
Cable Voltage Rating (kV)	Test Voltages (Vt) Corresponding to Vt/Vg Ratio (kV)				
5	3.0	4.5	7.0	8.5	11.5
8	4.5	7.0	11.5	14.0	18.5
15	8.5	13.0	21.5	26.0	35.0

6. Flame test. For construction that is UL labeled "Type MV-90 FOR CT USE", provide data verifying that the cable design has passed a UL vertical tray flame test in accordance with UL 1072.

3. EXECUTION

3.1 INSTALLATION

A. Comply with the provisions of ANSI/IEEE C2 and all state and local laws, rules, and regulations for installing electric wires and equipment.

B. Pulling tension: Provide end-to-end pulling tension calculations for each cable installation; include details of pulling devices, lubricants, sheaves, and sheave assemblies. Obtain cable manufacturer's concurrence with the calculations and installation techniques.

C. Terminations and connections: Install termination devices as indicated on project drawings and/or specifications, and in accordance with the manufacturer's installation instructions.

3.2 FIELD QUALITY CONTROL

A. Conduct a visual inspection for on-reel cable damage prior to installation.

1. Inspect for physical damage from shipping and handling.
2. Verify that factory-applied end seals are in-place and have not been damaged or repaired. Both cable ends should be exposed for a minimum of two feet to permit field testing prior to installation.
3. When end seals are removed for cable installation, inspect for evidence of moisture inside the cable, and for obvious signs of corrosion.
4. Prepare a visual inspection report. Report any damage to the Plant Engineering Electrical Supervisor for disposition prior to installation.

B. Perform a high voltage direct current (HVDC) acceptance test after cable and terminations are installed. Conduct test prior to making equipment connections. Comply with the requirements of the Medium-Voltage Cable Testing standard, D180-14302-3, vol III, Section 11. Report any test failure to the Plant Engineering Electrical Supervisor for disposition prior to repair and retest. Prior to conducting test, provide three days notice of intent-to-test to the Plant Engineering electrical supervisor.

* * * END OF SECTION * * *

SECTION 16130

BOXES

1. GENERAL

1.1 DESCRIPTION OF WORK

A. This section includes
   1. Wall outlet boxes.
   2. Pull and junction boxes.
   3. Underground handholes.

1.2 REFERENCES

A. UL 50 Electrical Cabinets and Boxes.

B. UL 514A Metallic Outlet Boxes.

C. WSDOT J-11b Washington State Department of Transportation, Junction Box Details, Standard Plan J-11b.

2. PRODUCTS

2.1 OUTLET BOXES

A. Sheet metal outlet boxes: UL 50; galvanized steel, with 1/2 inch male fixture studs where required.

B. Nonmetallic outlet boxes: UL 50. Use hubs and grounding bushings for installation.

C. Cast boxes: UL 50; cast feralloy, deep type with internal grounding screw, gasketed cover, threaded hubs.

2.2 PULL AND JUNCTION BOXES

A. Sheet metal boxes: UL 50; galvanized steel.

B. Sheet metal boxes larger than 12 inches in any dimension: Provide hinged enclosure.

C. Cast metal boxes for outdoor and wet location installations: UL 50; Type 4 and Type 6, flat-flanged, surface-mounted junction box, UL-listed as raintight. Galvanized cast-iron box and cover with ground flange, neoprene gasket, and stainless steel cover screws.

D. Cast metal boxes for underground installations: UL 50; Type 4, outside flanged, recessed cover box for flush mounting, UL-listed as raintight. Galvanized cast iron box and plain cover with neoprene gasket and stainless steel cover screws.

E. Concrete handholes for underground installations: Precast concrete conforming to Washington State Department of Transportation J-11b (WSDOT J-11b), type 4. Covers to be suitable for H-20 Load Test.

3. EXECUTION

3.1 COORDINATION OF BOX LOCATIONS

A. Provide electrical boxes as shown on Drawings, and as required for splices, taps, wire pulling, equipment connections, and code compliance.

B. Electrical box locations shown on Drawings are approximate unless dimensioned. Verify location of floor boxes and outlets in offices and work areas before roughing in.

C. Locate and install boxes to allow access.

D. Locate and install to present a neat appearance.

3.2 OUTLET BOX INSTALLATION

A. Provide knockout closures for unused openings.

B. Support boxes independently of conduit, except for cast boxes that are connected to two rigid metal conduits, both supported within 12 inches of box.

C. Use multiple-gang boxes where two or more devices are mounted together; do not use sectional boxes. Provide barriers to separate wiring of different voltage systems and for code compliance.

* * * END OF SECTION * * *

SECTION 16141

WIRING DEVICES

1. GENERAL

1.1 DESCRIPTION OF WORK

A. This section includes
   1. Receptacles.
   2. Device plates and box covers.

1.2 REFERENCES

A. FS W-C-596 Electrical Power Connector, Plug, Receptacle, and Cable Outlet.

B. NEMA WD 1 General-Purpose Wiring Devices.

C. UL 498 Attachment Plugs and Receptacles.

D. UL 943 Ground Fault Circuit Interrupters.

1.3 SUBMITTALS

A. Procedure: Conform to Specification Section 01300 - Submittal Procedures.

B. Submit product data showing configurations, finishes, dimensions, and manufacturer's instructions.

2. PRODUCTS

2.1 RECEPTACLES

A. General: Locking-blade and straight-blade receptacles; UL 498 and NEMA WD 1; configuration as indicated on the Drawings.

B. Convenience receptacle configuration: NEMA WD 1; Type 5-15 R, Ivory plastic face.

C. Specific-use receptacle configuration: UL 498 and NEMA WD 1; configuration as indicated on the Drawings.

D. GFIC receptacles: UL 943 and NEMA WD 1; duplex convenience receptacle with integral ground fault current interrupter.

E. Pin and sleeve receptacles: UL 498 or FS W-C-596; configuration as indicated on the Drawings.

2.2 WALL PLATES

A. Weatherproof cover plate: Gasketed cast metal with hinged gasketed device covers.

B. Attachment screws: stainless steel.

C. Device plates for exposed installations: By outlet box manufacturer.

3. EXECUTION

3.1 INSTALLATION

A. Install convenience receptacles 48 inches above grade, grounding pole on bottom.

B. Install specific-use receptacles at heights shown on the Drawings.

C. Install galvanized steel plates on outlet boxes and junction boxes in unfinished areas, above accessible ceilings, and on surface-mounted outlets.

D. Install devices and wall plates flush and level.

E. Identify each device in accordance with Section 16195, Electrical Identification.

* * * END OF SECTION * * *

SECTION 16195

ELECTRICAL IDENTIFICATION

1. GENERAL

1.1 DESCRIPTION OF WORK

A. This section includes
   1. Nameplates and tape labels.
   2. Wire and cable markers.
   3. Conduit color coding.

1.2 SUBMITTALS

A. Procedure: Conform to Specification Section 01300 - Submittal Procedures.

B. Submit Shop Drawings, including schedule for nameplates and tape labels.

2. PRODUCTS

2.1 MATERIALS

A. Nameplates: Engraved three-layer laminated plastic, black letters on a white background.

B. Tape labels: Embossed adhesive tape, with 3/16 inch white letters on black background.

C. Wire and cable markers: Cloth markers, split sleeve or tubing type.

3. EXECUTION

3.1 INSTALLATION

A. Degrease and clean surfaces to receive nameplates and tape labels.

B. Install nameplates and tape labels parallel to equipment lines.

C. Secure nameplates to equipment fronts using screws or rivets. Adhesives are not acceptable. Secure nameplate to inside face of recessed panelboard doors in finished locations.

D. Use embossed tape only for identification of individual wall switches and receptacles, and control device stations in dry interior locations. Do not use in process areas or exterior.

3.2 WIRE IDENTIFICATION

A. Provide wire markers on each conductor in panelboard gutters, pull boxes, outlet and junction boxes, and at load connection. Identify with branch circuit or feeder number for power and lighting circuits, and with control wire number as indicated on schematic and interconnection diagrams or equipment manufacturer's Shop Drawings for control wiring. All control wiring must be labeled with machine printed heat shrink type labels at all termination points.

B. Wire color coding:

1. Color code power wiring as indicated below.

SYSTEM		CONDUCTORS		
		A	B	C Neutral
208Y/120 Volts	Black	Red	Blue	White
480Y/277 Volts	Brown	Orange	Yellow	Gray

2. Insulated ground conductors: Green.
3. Isolated ground conductors: Green with a yellow trace.

C. If large conductors cannot be purchased with the correct insulation color, colors code the conductors with wire and cable markers of the appropriate color. Completely encircle the conductor with color coding for a minimum length of 6 inches.

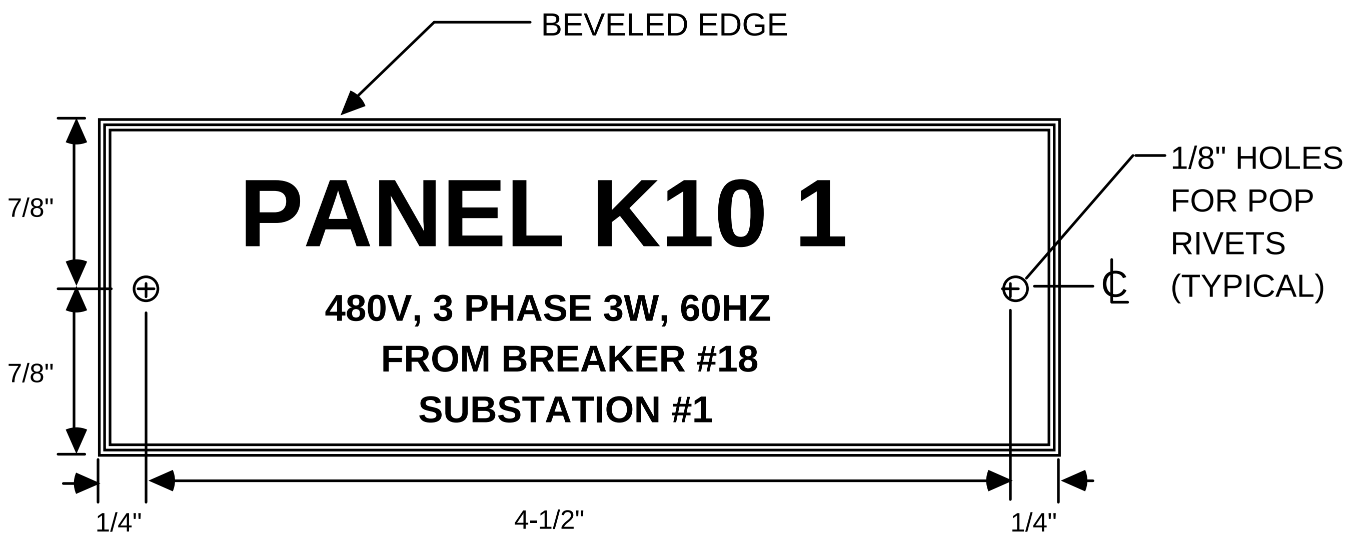
3.3 NAMEPLATE ENGRAVING SCHEDULE

A. Provide 1-3/4 inch high by 5 inches wide nameplates to identify all electrical distribution and control equipment. Letter height: 1/2 inch for distribution and control equipment identification.

B. See example in this section.

3.4 RECEPTACLE IDENTIFICATION

A. Provide tape labels on receptacle cover plates in dry locations. Provide engraved labels in wet locations, including process areas subject to hose down. Indicate panel and circuit breaker number feeding device.



NOTE: LETTERING ON FIRST LINE IS 3/8" HIGH. ALL OTHER LINES OF LETTERING ARE 1/8" HIGH WITH 1/8" SPACING BETWEEN LINES.

TYPICAL NAMEPLATE

NOT TO SCALE

FIGURE 1

* * * END OF SECTION * * *

SECTION 16321

DISTRIBUTION TRANSFORMERS

1. GENERAL

1.1 DESCRIPTION OF WORK

A. This section includes
   1. Liquid-filled pad-mounted distribution transformer.

1.2 REFERENCED STANDARDS

A. ANSI C37.47 Specifications for Distribution Fuse Disconnecting Switches, Fuse Supports, and Current- Limiting Fuses.

B. ANSI/IEEE C57.12.01 General Requirements for Dry-Type Distribution and Power Transformers.

C. ANSI C57.12.20 Requirements for Overhead Type Distribution Transformers, 500 kVA and Smaller: High- Voltage, 67000 Volts and Below; Low-Voltage, 15000 Volts and Below.

D. ANSI C57.12.22 Requirements for Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers with High-Voltage Bushings; High Voltage, 34500 GrdY/19920 Volts and Below; 2500 kVA and Smaller.

E. ANSI/IEEE C57.12.90 Test Code for Liquid-Immersed Distribution Power, and Regulating Transformers.

F. ANSI/IEEE C57.12.91 Test Code for Dry-Type Distribution and Power Transformers.

G. ANSI/IEEE C57.13 Requirements for Instrument Transformers.

H. ANSI/IEEE 386 Separable Insulated Connector Systems for Power Distribution Systems above 600 V.

I. ASTM D 877 Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes.

J. NEMA AB1 Molded Case Circuit Breakers.

K. NEMA 260 Safety Labels for Padmounted Switchgear and Transformers Sited in Public Areas.

1.3 SUBMITTALS

A. Shop Drawings indicating outline dimensions, connection and support points, weight, specified ratings and materials.

B. Product data indicating standard model design tests and options.

C. Manufacturer's installation instructions.

D. Operation and maintenance data, including procedures for sampling and maintaining fluid, cleaning unit, and replacing components.

1.4 QUALITY ASSURANCE

A. Manufacturer: Company specializing in distribution transformers with 3 years of documented experience.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Store and protect products until final installation. Coordinate laydown areas with Owner.

B. Protect dry-type transformers from moisture by using appropriate heaters as instructed by the manufacturer.

2. PRODUCTS

2.1 PAD-MOUNTED TRANSFORMERS

A. Liquid-filled Transformers: ANSI C57.12.22; three-phase, pad-mounted, self-cooled transformer unit.

B. Capacity: 500 kVA.

C. Primary voltage: 4.16 kV, delta connected; provide standard primary taps, with externally operated tap changer.

D. Secondary voltage: 480/277 volts, wye connected.

E. Impedance: 5.75%, tolerance ± 7.5%.

F. Basic impulse level: 30 kV.

G. Cooling and temperature rise; ANSI C57.12.22; Class OA. [55°] [65°] C, self-cooled.

H. Liquid: Oil.

I. Accessories: ANSI C57.12.22 standard accessories.

J. Cooling and temperature rise: ANSI/IEEE C57.12.01; Class AA. 220° C insulation class with 150° C rise over 40° C ambient.

K. Primary terminations: Bushing wells to ANSI/IEEE 386; provide three for radial feed. Include bushings for insulated loadbreak connectors.

L. Primary switching: Internal oil-immersed gang-operated load break switch.

M. Primary overcurrent protection: Internally-mounted, oil-immersed, expulsion fuses.

N. Secondary terminations: Spade lugs.

3. EXECUTION

3.1 EXAMINATION

A. Verify that pad and vault are ready to receive work.

B. Verify field measurements are as shown on the Drawings and as instructed by manufacturer.

C. Verify that required utilities are available, in proper location and ready for use.

D. Beginning of installation means installer accepts conditions.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install safety labels to NEMA 260.

3.3 FIELD QUALITY CONTROL

A. Field testing shall be performed per manufacturer's recommendations.

B. Test dielectric liquid to ASTM D 877, using 25,000 volts minimum breakdown voltage after installation and before energizing from system.

C. Test transformer to ANSI/IEEE C57.12.90.

3.4 ADJUSTING

A. Adjust primary taps so that secondary voltage is within 2% of rated voltage.

* * * END OF SECTION * * *

SECTION 16470

PANELBOARDS

1. GENERAL

1.1 DESCRIPTION OF WORK

A. This section includes
   1. Distribution panelboards.

1.2 REFERENCES

A. NFPA 70-1994 National Electrical Code (NEC).

B. NEMA AB-1 Molded Case Circuit Breakers.

C. NEMA PB-1 Panelboards.

D. NEMA PB-1.1 Instructions for Safe Installation, Operation, and Maintenance of Panelboards Rated 600 Volts or less.

E. NEMA PB-2.2 Application Guide for Ground-fault Protective Devices for Equipment.

F. UL50 Electrical Cabinets and Boxes.

G. UL67 Panelboards.

H. UL489 Molded Case Circuit Breakers.

1.3 SUBMITTALS

A. Submit shop drawing, specification sheet, and evidence of UL listing/labeling for each panelboard assembly and each component device. Submit proof of UL testing for each door-in-door design and for door latch/latch-spacing design. Submit proof that each panelboard design has been investigated and found to be adequate to meet the requirements of the NEC, including box wiring space.

B. Include outline dimensions, mounting or support point dimensions, bus capacity, breaker hardware capacity, asymmetrical short circuit interrupting rating, circuit breaker sizes, circuit breaker locking device, circuit breaker arrangement, and short circuit/fault studies (as scheduled).

C. Include detailed panelboard description that correlates to the individual panelboard schedule(s) and specification sheet(s). See Section 3.3.

2. PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. General Electric.

B. Westinghouse.

C. Square-D.

D. Other manufacturers are acceptable provided that:
   1. Circuit breakers are new UL listed/labeled products manufactured within twelve months prior to panelboard delivery by one of the manufacturers listed in Section 2.1A, B & C above.
   2. The enclosure design, door/trim design, door-latch design, and panelboard interior are UL listed and labeled.
   3. Written evidence is submitted to verify that the panelboard and electrical cabinet box/front assembly has been investigated and found to be adequate to meet the requirements of the NEC, including box wiring space.
   4. The manufacturer is acceptable to the Engineer.

E. Substitutions: Any substitution and/or deviation from these specifications must be approved by the Engineer prior to fabrication and delivery.

2.2 DISTRIBUTION PANELBOARDS

A. Distribution panelboards: NEMA PB-1 and UL67; deadfront-type safety construction. Provide UL label for use as service entrance equipment.

B. Enclosure: NEMA PB-1 and UL50. NEMA type and mounting as scheduled. Cabinet size to accommodate specified wire bending space. Fabricate using code gage galvanized steel without knockouts. Provide removable top and bottom end panels. Finish with rust-inhibiting paint; NEMA 3R type enclosure for exterior installation.

C. Interiors: Provide interior designed to permit circuit breaker replacement and/or re-configuration without disturbing adjacent units, without removing main bus connectors, and without requiring machining, drilling, or tapping.

D. Wire bending space: NEC Article 384; provide code-required wire bending space sized for 600 kcmil maximum conductors entering or leaving the enclosure. Provide side wire bending space with full capacity for all circuit breaker positions, including future additions, and sized for 4/0 AWG maximum conductors terminating in that space; typical for both sides.

E. Panelboard cover: UL 50. Provide door-in-door construction with full-length hinges on each door; one door over the deadfront interior (inner door) and one that provides access to the distribution breaker wireways (outer door). For doors with dimension over forty-eight inches, fabricate using minimum 12-gage steel. Doors must open and close with repeated use, and properly latch, without binding or warping. Apply 2 coats of manufacturer's standard light gray finish over a rust-inhibiting primer to exterior and interior surfaces. Finish must pass NEMA standard tests for 3R/12 enclosures.

F. Latches-inner door: Provide metallic, spring-return, flush latches with cylinder-type key locks. Provide multiple latches on doors over thirty inches high; maximum spacing twenty-four inches. Provide common key for multiple latches.

G. Latches-outer door: Provide UL approved, screwdriver operated, metallic 1/4-turn. Provide multiple latches on doors over thirty inches high. Latch spacing as required to meet UL standards for short-circuit testing; twenty-four inches maximum spacing.

H. Circuit directory: Provide permanently mounted circuit directory holder on the inside surface of the inner door. Fabricate from non-yellowing, break-resistant polycarbonate. Size to accept a 8.5 x 11-inches directory card. Metallic frame is permitted.

I. Nameplates: Provide factory-installed 5 inches wide x 1-inch high laminated plastic nameplate with engraved panel number as scheduled. Black background with white lettering in 1/2-inch high characters. Permanently mount on front of panel cover directly above the inner door. Adhesive-backed nameplates are not acceptable.

J. Bus ratings: Provide panelboards with main copper bus; rating as scheduled; bus phasing "A", "B", "C" from left to right when facing front of panelboard. Provide main bus and breaker mounting hardware for all positions including scheduled "spaces" for future breakers; suitably insulated and braced for panelboard short circuit rating.

K. Grounding bar: Provide a UL approved copper equipment grounding bar, bonded to the enclosure as scheduled. Provide suitable lugs for all pole positions and for the incoming grounding conductor(s) as scheduled. Mount below neutral bar at end of panelboard not used for main breaker and increase wire bending space to maintain code-required clearances.

L. Short circuit rating: Provide short circuit interrupting capability, to meet or exceed the scheduled ratings. Series-rated assemblies are not acceptable.

M. Main circuit breaker: Provide factory-installed solid state; bolted in place; location in panelboard as scheduled. Provide cable connecting lugs on line side of breaker and a barrier or line shield to prevent accidental exposure to live parts when the panel cover is removed. Sizes, ratings, options, and accessories as scheduled. Ampere rating must be clearly visible without removing trim. Provide padlockable handle attachment.

N. Distribution circuit breakers: Provide factory-installed molded case circuit breakers and directed arrangement as scheduled. Ampere rating must be clearly visible without removing trim. Provide padlockable handle attachment for each circuit breaker. Provide factory-installed, laminated plastic, breaker position identification plates to match panel schedule numbering; white letters on black background; permanently mount on interior trim adjacent to breaker positions.

O. Molded case circuit breakers: NEMA AB-1 and UL489; provide bolt-on type circuit breakers with integral solid state trip in each pole. Where scheduled, provide circuit breakers UL listed and labeled for type HACR service or SWD switching duty. Provide non-welding silver alloy contacts; arc-extinguishing chutes consisting of metal grid plates mounted on heat-absorbing insulating supports; ground and polished latch surfaces; and quick-make, quick-break operating mechanism with toggle-type handle. All poles open, close, and trip simultaneously. Tripped condition indicated automatically by the operating handle moving to a position half way between the extreme ON and OFF positions.

3. EXECUTION

3.1 INSTALLATION

A. Panelboard installation: NEMA PB-1.1; Install plumb and level. Install flush with wall finishes (where scheduled to be flush mounting).

B. Height: Unless otherwise scheduled on the Drawings install branch-circuit panelboards with top of enclosure at six feet above finished floor or exterior grade. Install distribution panelboards so that the center of the operating handle grip (when in its highest position) of the top-most circuit breaker is not greater than 6'-6" above the finished floor or exterior grade.

C. Provide filler plates for all unused spaces in panelboards.

D. Balance phase loads within plus or minus ten percent in each panelboard. Revise circuit directory to reflect circuiting changes.

3.2 FIELD QUALITY CONTROL

A. Measure steady state load currents at each panelboard feeder. If a difference greater than ten percent exists between phases in any panelboard, rearrange circuits to balance the phase loads to within ten percent. Maintain proper phasing for multi-wire branch circuits.

B. Visual and mechanical inspection: Prior to energizing any panelboard or load center, visually inspect for physical damage, proper alignment, anchorage, and grounding; and physically check proper installation and tightness of connections for all circuit breakers. Correct all discrepancies prior to energization and acceptance.

3.3 PANELBOARD SCHEDULE(S)

A. The attached Electrical Panel Schedules for panelboards and load centers form a part of this specification (See Appendix A). Each schedule includes a Panel Schedule sheet and a Data/Specification sheet.

* * * END OF SECTION * * *

APPENDIX A

(TO SECTION 16470 – PANELBOARDS)

ELECTRICAL PANEL SCHEDULE

Electrical Panel Schedule

Location : EXT. WALL, LIFT STATION 431
Building : 3.YD
Panel Name : 3.YD-370-A

Panel Type :
AIC Rating (amps) : 10,000
Installation Date :

Main Bkr : 800A
Revised Circuits :

Rating : 800A, 480Y/277V, 3PH, 4W
Date Revised :

Br Bkrs :
Engineer : URS

Feeders : (2) 4"C, 3-500KCMIL, #3G
Job number : 972108-00

From : PAD 397A
Ref Dwg : E4B
Rev :

via : 500KVA, 4160-480-277V

Rev Date	Ckt No	Breaker - Amps/Poles	Wire Size	Load Description	Amps a	Amps b	Amps c	Location
	1a	/	500		320			
	3b	400/3	500	TREATMENT PLANT		320		
	5c	/	500				320	
	7a	/	#10		21			
	9b	30/3	#10	PUMP P-201 VFD		21		
	11c	/	#10				21	
	13a	20/2	#12	MPZ-5KVA TRANSFORMER	5.2			
	15b	/	#12			5.2		
	17c	/						
	19a	/						
	21b	/						
	23c	/						
	25a	/						
	27b	/						
	29c	/						
	31a	/						
	33b	/						
	35c	/						
	37a	/						
	39b	/						
	41c	/						
	2a	/						
	4b	/						
	6c	/						
	8a	/						
	10b	/						
	12c	/						
	14a	/						
	16b	/						
	18c	/						
	20a	/						
	22b	/						
	24c	/						
	26a	/						
	28b	/						
	30c	/						
	32a	/						
	34b	/						
	36c	/						
	38a	/						
	40b	/						
	42c	/						

Notes :
NEAR LIFT STATION 431

Electrical Panel Schedule

Location : EXT. WALL, LIFT STATION 431 **Building :** 3.YD. **Panel Name :** 3.YD-370-MPZ

Panel Type : **AIC Rating (amps) :** 10,000 **Installation Date :**

Main Bkr : **Revised Circuits :**

Rating : 100A, 208Y/120V, 3PH, 4W **Date Revised :**

Br Bkrs : **Engineer :** URS

Feeders : 3/4"C, (2)#12AWG, (1)#12AWG, GND **Job number :** 972108-00

From : PNL 3.YD-370-A **Ref Dwg :** E4B **Rev :**

via : MINI PWR ZONE TRANSFORMER

Rev Date	Ckt No	Breaker - Amps/Poles	Wire Size	Load Description	Amps a	Amps b	Amps c	Location
	1a	20/1	#12	RECP. GFCI	0.18			
	3b	20/1	#12	FLOW METER		0.2		
	5c	20/1	#12	FLOW METER			0.2	
	7a	20/1	#12	LEVEL TRANSDUCER	0.3			
	9b	20/1	#12	LEVEL TRANSDUCER		0.3		
	11c	20/1		SPARE				
	2a	20/1		SPARE				
	4b	20/1		SPARE				
	6c	20/1		SPARE				
	8a	20/1		SPARE				
	10b	20/1		SPARE				
	12c	20/1		SPARE				

Notes :

SECTION 16510

LIGHTING

1. GENERAL

1.1 DESCRIPTION OF WORK

A. This section includes
   1. Exterior luminaires and accessories.
   2. Lamps.
   3. Ballasts.

1.2 REFERENCES

A. ANSI C82.4 Specifications for High-Intensity-Discharge Lamp Ballasts (Multiple Supply Type).

B. NEMA LE 2 H-I-D Lighting System Noise Criterion (LS-NC) Ratings.

C. UL 1572 High Intensity Discharge Lighting Fixtures.

1.3 SUBMITTALS

A. Procedure: Conform to Specification Section 01300 - Submittal Procedures.

B. Submit product data for item.

C. Include outline Drawings, lamp and ballast data, support points, weights, and accessory information for each luminaire type.

D. Submit manufacturer's installation instructions.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site as directed by the Owner.

B. Store and protect products until final installation in locations approved by the Owner.

2. PRODUCTS

2.1 EXTERIOR LUMINAIRES AND ACCESSORIES

A. Enclosures: Complete with gaskets to form weatherproof assembly.

B. Provide low temperature ballasts, with reliable starting to -20°F.

2.2 ACCEPTABLE MANUFACTURERS - LAMPS

A. General Electric.

B. Sylvania.

2.3 LAMPS

A. Metal halide HID lamps: As scheduled on the Drawings. Clear.

2.4 HID BALLASTS

A. HID ballast: ANSI C82.4; suitable for 122°F (50°C) ambient.

B. LS-NC Rating: NEMA LE 2; equal to or less than ratings listed in Table C-1.

C. Inline fuse and fuse holder: Fuse each phase line. Fuse rating in accordance with ballast manufacturer's inrush and full load current data.

2.5 FUSES AND FUSE HOLDERS

A. Fuse and holder combination: Time-delay, Bussmann GMF, or approved.

3. EXECUTION

3.1 INSTALLATION

A. Install lamps in luminaires and lampholders.

B. Install pole foundation as shown on the Drawings. Install anchor bolts as directed by the pole manufacturer. Do not install pole until foundation has cured.

3.2 RELAMPING

A. Relamp luminaires which have failed lamps at completion of Work.

3.3 ADJUSTING AND CLEANING

A. Align luminaires and clean lenses and diffusers at completion of Work. Clean paint splatters, dirt, and debris from installed luminaires and poles.

B. Touch up luminaire finish at completion of Work.

* * * END OF SECTION * * *

SECTION 16800

VARIABLE FREQUENCY DRIVE MOTOR CONTROLLERS

1. GENERAL

1.1 DESCRIPTION OF WORK

A. This section includes separately enclosed, pre-assembled, combination VFDs, rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.

1.2 DEFINITIONS

A. BAS: Building automation system.

B. CE: Conformite Europeene (European Compliance).

C. CPT: Control power transformer.

D. EMI: Electromagnetic interference.

E. IGBT: Insulated-gate bipolar transistor.

F. LAN: Local area network.

G. LED: Light-emitting diode.

H. MCP: Motor-circuit protector.

I. NC: Normally closed.

J. NO: Normally open.

K. OCPD: Overcurrent protective device.

L. PID: Control action, proportional plus integral plus derivative.

M. PWM: Pulse-width modulated.

N. RFI: Radio-frequency interference.

O. VFD: Variable-frequency motor controller.

1.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: VFDs shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified.

1.4 SUBMITTALS

A. Procedure: Conform to Specification Section 01300 - Submittal Procedures.

B. Product Data: For each type and rating of VFD indicated.

C. Shop Drawings: For each VFD indicated. Include dimensioned plans, elevations, and sections; and conduit entry locations and sizes, mounting arrangements, and details, including required clearances and service space around equipment.
   1. Show tabulations of installed devices, equipment features, and ratings.
   2. Schematic and Connection Wiring Diagrams: For power, signal, and control wiring.

D. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around VFDs. Show VFD layout and relationships between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.

E. Seismic Qualification Certificates: For VFDs, accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based, and their installation requirements.

F. Product certificates.

G. Source quality-control reports.

H. Field quality-control reports.

I. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NFPA 70.

D. IEEE Compliance: Fabricate and test VFD according to IEEE 344 to withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace VFDs that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: Five years from date of Substantial Completion.

2. PRODUCTS

2.1 MANUFACTURED UNITS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

B. Basis-of-Design Product:
   1. Rockwell Automation, Inc.; Allen-Bradley Powerflex 70.

C. General Requirements for VFDs: Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 508C.

D. Application: variable torque.

E. VFD Description: Variable-frequency power converter (rectifier, dc bus, and IGBT, PWM inverter) factory packaged in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.
   1. Units suitable for operation of NEMA MG 1, Design A and Design B motors as defined by NEMA MG 1, Section IV, Part 30, "Application Considerations for Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and General Purpose Motors Used with Adjustable-Voltage or Adjustable-Frequency Controls or Both."
   2. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."
   3. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.

F. Design and Rating: Match load type, such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.

G. Output Rating: Three-phase; 0 to 60 Hz, with voltage proportional to frequency throughout voltage range. Maximum voltage equals input voltage.

H. Unit Operating Requirements:
1. Input AC Voltage Tolerance: Plus 10 and minus 10 percent of VFD input voltage rating.
2. Input AC Voltage Unbalance: Not exceeding 3 percent.
3. Input Frequency Tolerance: Plus or minus 3 percent of VFD frequency rating.
4. Minimum Efficiency: 96 percent at 60 Hz, full load.
5. Minimum Displacement Primary-Side Power Factor: 96 percent under any load or speed condition.
6. Minimum Short-Circuit Current (Withstand) Rating: 10 kA.
7. Ambient Temperature Rating: Not less than 14 deg F (minus 10 deg C) and not exceeding 104 deg F (40 deg C).
8. Ambient Storage Temperature Rating: Not less than minus 4 deg F (minus 20 deg C) and not exceeding 140 deg F (60 deg C)
9. Humidity Rating: Less than 95 percent (noncondensing).
10. Altitude Rating: Not exceeding 3300 feet (1005 m).
11. Vibration Withstand: Comply with IEC 60068-2-6.
12. Overload Capability: 1.1 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.
13. Starting Torque: Minimum 100 percent of rated torque from 3 to 60 Hz.
14. Speed Regulation: Plus or minus 5 percent.
15. Output Carrier Frequency: Selectable; 0.5 to 15 kHz.
16. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.

I. Inverter Logic: Microprocessor based, 32 bit, isolated from all power circuits.

J. Isolated Control Interface: Allows VFDs to follow remote-control electrical signal over a minimum 40:1 speed range.

K. Internal Adjustability Capabilities:
1. Minimum Speed: 5 to 25 percent of maximum rpm.
2. Maximum Speed: 80 to 100 percent of maximum rpm.
3. Acceleration: 0.1 to 999.9 seconds.
4. Deceleration: 0.1 to 999.9 seconds.
5. Current Limit: 30 to minimum of 150 percent of maximum rating.

L. Self-Protection and Reliability Features:

1. Input transient protection by means of surge suppressors to provide three-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
2. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
3. Under- and overvoltage trips.
4. Inverter overcurrent trips.
5. VFD and Motor Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFDs and motor thermal characteristics, and for providing VFD overtemperature and motor overload alarm and trip; settings selectable via the keypad; NRTL approved.
6. Critical frequency rejection, with three selectable, adjustable deadbands.
7. Instantaneous line-to-line and line-to-ground overcurrent trips.
8. Loss-of-phase protection.
9. Reverse-phase protection.
10. Short-circuit protection.
11. Motor overtemperature fault.

M. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.

N. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped, unless "Bidirectional Autospeed Search" feature is available and engaged.

O. Bidirectional Autospeed Search: Capable of starting VFD into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.

P. Integral Input Disconnecting Means and OCPD: Provide as recommended by the equipment manufacturer appropriate to the location and environment where installed with pad-lockable, door-mounted handle mechanism.
   1. Disconnect Rating: Not less than 115 percent of VFD input current rating.

2.2 CONTROLS AND INDICATION

A. Status Lights: Door-mounted LED indicators displaying the following conditions:
   1. Power on.
   2. Run.
   3. Overvoltage.
   4. Line fault.
   5. Overcurrent.
   6. External fault.

B. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.
   1. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.
   2. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.
      a. Control Authority: Supports at least four conditions: Off, local manual control at VFD, local automatic control at VFD, and automatic control through a remote source.

C. Historical Logging Information and Displays:
   1. Running log of total power versus time.
   2. Total run time.
   3. Fault log, maintaining last four faults with time and date stamp for each.

D. Indicating Devices: Digital display mounted flush in VFD door and connected to display VFD parameters including, but not limited to:
   1. Output frequency (Hz).
   2. Motor speed (rpm).
   3. Motor status (running, stop, fault).
   4. Motor current (amperes).
   5. Motor torque (percent).
   6. Fault or alarming status (code).
   7. PID feedback signal (percent).
   8. DC-link voltage (V dc).
   9. Set point frequency (Hz).
   10. Motor output voltage (V ac).

E. Control Signal Interfaces:
   1. Electric Input Signal Interface:
      a. A minimum of two programmable analog inputs: 0- to 10-V dc and 4- to 20-mA dc
      b. A minimum of six multifunction programmable digital inputs.
   2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the BAS or other control systems:
      a. 0- to 10-V dc.
      b. 4- to 20-mA dc.
      c. Potentiometer using up/down digital inputs.
      d. Fixed frequencies using digital inputs.
   3. Output Signal Interface: A minimum of one programmable analog output signal(s) (0- to 10-V dc or 4- to 20-mA dc operator-selectable "x"- to "y"-mA dc, which can be configured for any of the following:
      a. Output frequency (Hz).
      b. Output current (load).
      c. DC-link voltage (V dc).

d. Motor torque (percent).
e. Motor speed (rpm).
f. Set point frequency (Hz).

4. Remote Indication Interface: A minimum of two programmable dry-circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
   a. Motor running.
   b. Set point speed reached.
   c. Fault and warning indication (overtemperature or overcurrent).
   d. PID high- or low-speed limits reached.

F. PID Control Interface: Provides closed-loop set point, differential feedback control in response to dual feedback signals. Allows for closed-loop control of fans and pumps for pressure, flow, or temperature regulation.
   1. Number of Loops: One

2.3 ENCLOSURES

A. VFD Enclosures: NEMA 250, to comply with environmental conditions at installed location.
   1. Outdoor Locations: Type 4X (VFD's located in an exterior waterproof control cabinet pressurized/ ventilated/ cooled with conditioned air are defined as: Dry and Clean Indoor Locations)

2.4 ACCESSORIES

A. General Requirements for Control-Circuit and Pilot Devices: NEMA ICS 5; factory installed in VFD enclosure cover unless otherwise indicated.
   1. Push Buttons, Pilot Lights, and Selector Switches: Standard-duty, type.
      a. Push Buttons: Unguarded momentary.
      b. Pilot Lights: Incandescent types;
      c. Selector Switches: Rotary or digital type.

2.5 SOURCE QUALITY CONTROL

A. Testing: Test and inspect VFDs according to requirements in NEMA ICS 61800-2
   1. Test each VFD while connected to its specified motor.
   2. Verification of Performance: Rate VFDs according to operation of functions and features specified.

B. VFDs will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3. EXECUTION

3.1 INSTALLATION

A. Wall-Mounting Controllers: Install VFDs on walls or unistrut with tops at uniform height and with disconnect operating handles not higher than 79 inches (2000 mm) above finished floor unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not on walls, provide freestanding racks.

B. Install fuses in control circuits if not factory installed. Install heaters in thermal-overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.

C. Install, connect, and fuse thermal-protector monitoring relays and leak detection relays furnished with motor-driven equipment.

D. Comply with NECA 1.

3.2 IDENTIFICATION

A. Identify VFDs, components, and control wiring. Comply with requirements for identification specified in Section 16195, Electrical Identification.
   1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
   2. Label each VFD with engraved nameplate.
   3. Label each enclosure-mounted control and pilot device.

3.3 CONTROL WIRING INSTALLATION

A. Install wiring between VFDs and remote devices.

B. Bundle, train, and support wiring in enclosures.

C. Connect selector switches and other automatic control devices where applicable.
   1. Connect selector switches to bypass only those manual- and automatic control devices that have no safety functions when switches are in manual-control position.
   2. Connect selector switches with control circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each VFD element, bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections:
1. Inspect VFD, wiring, components, connections, and equipment installation.
2. Test insulation resistance for each VFD element, component, connecting motor supply, feeder, and control circuits.
3. Test continuity of each circuit.
4. Verify that voltages at VFD locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Owner before starting the motor(s).
5. Test each motor for proper phase rotation.
6. Perform each electrical test and visual and mechanical inspection stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
8. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

D. VFDs will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies the VFD and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.5 ADJUSTING

A. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.

B. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

* * * END OF SECTION * * *